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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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See Advertisement page 42, June 8. 6402

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In the Matter of CREED & COMPANY, LIMITED (and Reduced).
and
In the Matter of the COMPANIES' ACTS, 1908 and 1913.

Notice is Hereby Given

that a Petition presented to the High Court of Justice, Chancery Division on the 5th day of April, 1917, for confirming a resolution reducing the capital of the above-named Company from £130,000 to £90,000, is directed to be heard before His Lordship MR. JUSTICE EVE, on Tuesday, the 24th day of July, 1917.
HAIR & CO.,
of 7, St. Mildred's Court,
Poultry, E.C.2. H 245
Solicitors for Company.

The Nieuport & General Aircraft COMPANY, LTD., wish it to be known that their ONLY ADDRESS is:—LANGTON ROAD, CRICKLEWOOD, LONDON, N.W.2. This Company has no authorised agents, and all communications should be addressed to the SECRETARY, as above. H 273

Glamorgan County Council.

SUMMER MINING AND ENGINEERING SCHOOL FOR SOUTH WALES COALFIELD.

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School of Technology
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PRINCIPAL: J. C. M. GARNETT, M.A. (late Fellow of Trinity College, Cambridge).

The SESSION 1917-18 will open on 8th OCTOBER. Matriculation and Entrance Examinations will be held in July and September.
The Prospectus, forwarded free on application, gives particulars of the courses leading to the Manchester University degrees in the Faculty of Technology, and of the provision for Advanced Study and Research in the following departments:—
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MINING,
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Intending students may enrol for the Session 1917-18 from 1st August, 1917. Members of the University under 18 years of age are eligible for membership of the Officers' Training Corps. H 1

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ENGINEERING AND TRADE SCHOOL.

Headmaster: JAMES G. B. EDWARDS, A.M.I.M.E.

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Ability to assist in Sports, Drill, &c., will be a recommendation.
NOTE.—For positions (c) and (d) Practical Workshop experience is essential.
Commencing salary £160 per annum.
Candidates must be ineligible for military service.
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Application forms, which must be returned not later than 31st July, may be obtained from
R. DEMPSEY,
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2, Tower Chambers, Hoe Street Bridge, Walthamstow, E. 17. H 271

NEWCASTLE-UPON-TYNE EDUCATION COMMITTEE.

LECTURER IN ENGINEERING, RUTHERFORD TECHNICAL COLLEGE.

The Council of the College invite

Applications for the Above APPOINTMENT from Gentlemen ineligible for or exempted from military service, and having College training and good experience in works, drawing offices, and engineering laboratories.

Preference will be given to candidates having experience in modern marine engineering practice. The appointment is for the duration of the War, and the salary is £250 to £300 per annum, according to qualification and experience.
Applications must be made on forms to be obtained from the undersigned, from whom further particulars may be obtained, on receipt of a stamped addressed foolscap envelope.
Applications must be sent in not later than 21st July, 1917.
PERCIVAL SHARP,
Director of Education.
Education Office,
Northumberland Road,
Newcastle-upon-Tyne. H 164

PORT-OF-SPAIN CITY COUNCIL.

POST OF CITY ENGINEER.

The Port-of-Spain City Council invite

Applications for the Post of CITY ENGINEER and ENGINEER OF WATER AND SEWERAGE WORKS, with which is associated also the general supervision of the management of the Woodbrooke Estate and the Cocorite Farm.

2. The salary attached to the post is £600 a year, rising by annual increments of £25 a year to a maximum of £750, with an allowance of £75 a year, towards the upkeep of a motor vehicle for the performance of his duties.
3. The appointment is subject to the approval of the Governor.
4. The office is pensionable under the Port-of-Spain Corporation Ordinance, 1914.
5. Salary will commence from the date of arrival in Trinidad. No allowance is made in respect of passage.
6. Candidates must submit evidence of their being corporate members of the Institution of Civil Engineers of England, and of possessing experience in the designing, construction and maintenance of waterworks and sewerage systems.
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10. The successful candidate must be prepared to take up the duties of his office within three months of the date of his receiving the official intimation from the Town Clerk that his appointment has been approved by the Governor.
11. Applications, accompanied by not more than two recent testimonials (one of which should be from the candidate's present employers), and stating age and previous experience, together with a medical certificate that the candidate is fit for service in the West Indies, must reach the Town Clerk, Port-of-Spain, Trinidad, not later than the 1st December, 1917.
PHILIP H. SALOMON,
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Town Hall,
Port-of-Spain,
Trinidad, B.W.I. H 110

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Applicants must have had works experience and a knowledge of mining chemical practice, and must be capable of conducting testing work.
Only candidates ineligible for military service need apply.
Salary according to qualifications and experience.
For further particulars apply to—
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Treforest, H 220
South Wales.

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Applications are Invited for the POSITION of CHIEF ENGINEER of the above Company. Applicants are requested to state previous experience, and to send copies of testimonials to the SECRETARY at the Office of the Company, Paradise Street, Birmingham, not later than 21st July, 1917. H 190

Woolwich Polytechnic.—

WANTED for September and for duration of war, with possible permanency, a TEACHER of Engineering subjects in Day and Evening Classes. Must be ineligible for Military service. Salary by arrangement according to past experience and qualifications.—Apply, PRINCIPAL. H 210

Metallurgists and METALLURGICAL CHEMISTS (temporary) REQUIRED.

Commencing salary £300 per annum.

Applications, giving full particulars of qualifications and experience to be forwarded to the

SUPERINTENDENT OF RESEARCH,
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Woolwich.

H 87

Chemist (Works), used to general metallurgical analysis. No person already engaged on Government work need apply.—State full particulars at your nearest EMPLOYMENT EXCHANGE, quoting reference No. A 3336. H 117

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Wanted, by Controlled Firm, WORKS MANAGER with good all round knowledge of engineering trade and up-to-date methods. Must be six o'clock man. Give particulars of experience, age, and salary required. No person employed on Government work will be engaged.—Address, H 183, Offices of ENGINEERING.

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Wanted, a Thoroughly Qualified MANAGER, to undertake the general management of a section of this Company's mines and crude oil works. Applicants must have a sound theoretical and practical training, with good experience of mining work, combined with knowledge of mechanical and electrical engineering.—Applications to be sent to the SECRETARY of the Company, 135, Buchanan Street, Glasgow. H 236

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Engineer Assistant Required by Westminster firm of engineers, working on urgent war work. Must have experience in out estimates, tenders, taking out quantities and the checking of drawings. No one employed on Government work or resident more than 10 miles away will be engaged.—Write, E.M. 044, care of DEACON'S, Leadenhall Street, E.C. 3, giving particulars of practical and theoretical training. H 233

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Also an Experienced MAN to arrange and control a piece-work system.
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Draughtsman Wanted, thoroughly capable, for large blast furnace and steel works plant. State age, experience, salary required, and when at liberty. No one already employed on Government work will be engaged.—Apply, your nearest EMPLOYMENT EXCHANGE, quoting No. A 3295. G 996

Wanted, Several First-class Mechanical DRAUGHTSMEN, with good all-round experience, for Admiralty work.—Apply (by letter only), stating age, experience, and present salary to BOX No. 1153, care of Messrs. R. F. WHITE & SON, Genl. Advng. Agents, 23, Fleet Street, E.C. 4. H 123

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Required, an Assistant Heating and Lighting ENGINEER or qualified DRAUGHTSMAN.—Send full particulars to H. ASHMEAD, H.M. Office of Works, King Charles Street, S.W.1. H 219

Draughtsman, Jig and Tool, WANTED for controlled establishment, Clyde district. No person already on Government work will be engaged.—Apply your nearest EMPLOYMENT EXCHANGE, quoting No. A3397. H 213

Wanted, Good Jig and Tool DRAUGHTSMAN, one with some varied experience preferred. State age, experience and salary required. Liverpool district.—Apply, your nearest EMPLOYMENT EXCHANGE, mentioning this Paper and H 224.

Draughtsman (Mechanical), one used to Jig and Toolwork preferred, WANTED by Midland firm manufacturing ball and roller bearings for aircraft and mechanical transport. Good salary according to experience. No man already on Government work can be engaged.—Application in the first instance should be made to your nearest EMPLOYMENT EXCHANGE, mentioning this Paper and No. A3390. H 217

There are Vacancies in a large Aeroplane Works, London, N.W., for the following permanent and progressive positions. Previous experience of aeroplane work is not necessary.
JIG and TOOL DRAUGHTSMEN.
FACTORY and PLANT LAY OUT DRAUGHTSMAN.
MANUFACTURING PROCESS MAN.
No person living more than ten miles away or already on Government work need apply.
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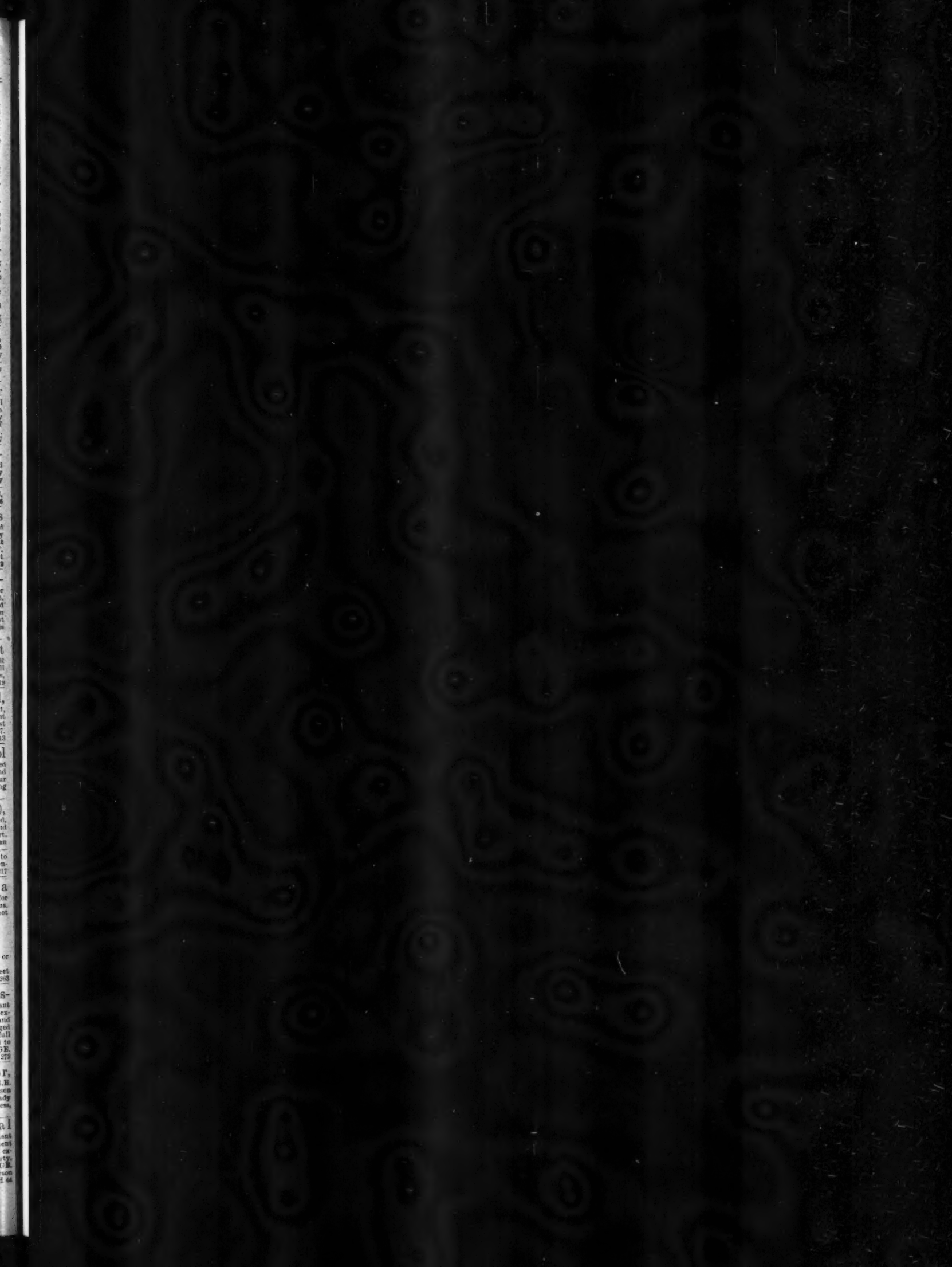
Several Mechanical Draughtsmen REQUIRED immediately for important War Work; also Detailers and Tracers with experience of Steam Plant, Conveying Plant and general factory work. No person already engaged on Government work need apply.—State full experience, when at liberty and wages required to your nearest EMPLOYMENT EXCHANGE quoting No. A 3431. H 272

Draughtsman, Junior, REQUIRED in Engineer's Office, S.E. District. State age and experience. No person resident more than 10 miles away or already engaged on Government work need apply.—Address, H 248, Offices of ENGINEERING.

Draughtsmen.—Several Juniors WANTED quickly for Government work in Midland Engineering Works. Permanent jobs for suitable men.—Apply, stating age, experience fully, salary expected, and when at liberty, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and No. A 3308. No person already on Government work will be engaged. H 46



POWER FOR THE FARM IN CANADA.

IN commenting recently upon the use of hydro-electric power in Canada and the success which had attended its development, it was mentioned that this success depended largely upon the ready response made to the demands of all classes. By satisfying a considerable number of varied and small applications a large load was uniformly distributed and effectively employed. Hence the scheme as planned was feasible wherever sufficient population existed. A voltage stepped-up to 100,000 volts could be distributed to large towns as Dundas, Hamilton and Toronto, where suitable provision could be made for reducing the voltage to 13,000, or some definite secondary voltage for transmission to smaller towns and villages, where it could be again transformed to 530 volts, 220 volts or 110 volts, as desired. So far the scheme could be worked satisfactorily, and though high voltages require expensive equipment and careful management, no insuperable difficulty is experienced and electric power can be brought at a fairly cheap rate to the doors of everyone within a moderate, but yet considerable, distance from Niagara. The price of power naturally varies according to distance from the central station. Hamilton pays 15 dols. per horse-power per year, St. Thomas 28, and Seaforth, more distant still, 40 dols. When power is distributed to scattered clients in sparsely inhabited districts a service charge becomes a necessity, varying in amount with the number of users in a township, 3 dols. per month being charged where there are three consumers to the mile, and 2 dols. when there are five. The point that we wish to make is that the natural resources provide the farmer throughout the entire province of Ontario with all the electric power he needs, and if it is rather expensive in isolated cases, he is encouraged to use the energy in a great variety of ways, that affords some compensation to the individual, while at the same time the load factor is improved and production generally is cheapened.

The position of the farmer in Manitoba and Saskatchewan is not so favourable. The sources of energy are much smaller, large towns like Winnipeg and Calgary absorb much of the available power and can—or very shortly will—utilise all they can get. The farmer, too, is less progressive than the town-bred citizen. The further he is removed from thronged centres of population and the bustle of cities, the more conservative he grows, and the more inclined to rely on his own resources. He is not educated up to the conveniences of electric washing machines, cream separators, and a host of other appliances that are regarded as necessaries by his Eastern competitor. The agriculturist is slow to move along the path of mechanical and economical progress. The horse-drawn single plough has a history as old as the hills whose surface it slowly and laboriously stirs: the application of mechanical power as a labour or time saving device is an innovation of yesterday. Germany, possessed with a profound appreciation of the material value of applied science, and forced to get the utmost out of its land, led the way in agricultural technology. After having tested the merits of the steam plough, she seized upon electricity as a motive power on the land, claiming that it works faster, is cheaper, and leaves less unutilised area in the field than other methods, and is particularly applicable to rough ground. Canada has not at present the same necessity to economise in land, but it should not be left out of sight that the German, availing himself of the speediness of the electric plough, is able to save so much time between the harvesting of one crop and the sowing of the next that he is able to raise two substantial crops annually on much of his land, harvesting on an average 2,600 acres of crops from 1,600 acres of land. Eastern Canada is able to compete with the German, thanks to the excellent system of electric transmission adopted; and notwithstanding the greater inertia of the Western farmer he is being slowly stimulated to take advantage of central service stations wherever these are available, and to employ mechanical substitutes where they are not. That he is on the alert, urged probably by the greater scarcity of manual labour, Mr. Beale's recent report on small water powers gives ample evidence; at the same time it exhibits the difficulties to which the pioneer who seeks to set up a small hydro-electric power station of his own is exposed.* In the prairie country, where agriculture is the main industry, the farms are scattered and cultivated with varying degrees of intensity. The streams are capricious and liable to failure: in the springtime the snow rapidly melts and for a short interval the collected precipitation of four or six months flows through the streams with a prodigality that is embarrassing when the discharge is not restrained by dams strong enough to resist the pressure of ice, logs and debris. This swift and ample flood once past, the flow drops to normal, but as the rainfall is comparatively light and easily absorbed by the soil, the run-off continually tends to diminish. In the winter the springs freeze solid, and the flow of all but the larger streams is stopped. A stream which has a flood discharge of possibly 500 second-feet may have no winter flow, and regarded as a power producer would be inoperative for four months in the year—a fatal objection to profitable investment. As a consequence such water power as exists is only useful to a settler who has the necessary mechanical skill and scientific knowledge to build a dam and set up the appropriate machinery himself. Notwithstanding this drawback, Mr. Beale is able to give instances in which farmers have successfully met all obstacles, and provided themselves with power sufficient for domestic and agricultural purposes all the year round. A typical instance is given in which a settler built his own power-house, and constructed from wood and sheet metal a 5-ft. inward flow, vertical turbine, with draught tube, cylinder gate, &c. The actual money expended on the initial installation was 160 dols., and by an outlay of 400 dols. he will have the command of 16 h.p. to 20 h.p. for six months of the year. This, of course, is a favourable case, but where technical knowledge is absent, or where foundations are insecure, and heavy spring floods bringing floating ice are frequent, it will not be wise to encourage the development of water power, either individually or collectively.

The outlook for the provision of long transmission lines is not encouraging under the adverse conditions mentioned. In another report, by Mr. H. A. Robson, K.C., on a "Projected Hydro-Electric System for the Province of Manitoba," it is pointed out that any effort to promote industrial development by large hydro-electric undertakings would entail heavy financial burdens on the province for many years. "The provision of electric service," says that authority, "merely for the use of the agriculturist, could not be accomplished on any satisfactory financial basis," and that the feasibility of such a scheme would depend on the growth of towns and villages to an extent that would supply a solid foundation for the enterprise. In some districts power is now sold at a lower price than the cost of production justifies, in order to induce industries to locate within a particular municipality. This practice cannot be recommended as sound finance, and if it be true, as alleged, that some plants show a profit where in reality a proper mode of accountancy would disclose a loss, the policy borders on a scandal. There is another, but happier, controlling factor which should not be overlooked, the progress of hydraulic development and electric transmission may be so marked as to reduce the costs of power within attractive limits.

The cost of generating and distributing power in Manitoba, as given by Mr. Robson, apparently from existing sources only, is calculated at 19.27 cents per kilowatt-hour, a charge that is practically prohibitive. In Edmonton the charge for power is 6 cents for the first 100 kw.-hour, falling to 2 cents when the number of hours exceeds 5,000. Apparently a rate as low as 3 cents per kilowatt-hour is in force, or is contemplated, in some parts of the Dominion, when the farmer's cost for ploughing will work out to something like the following figures. The average speed of an 80 h.p. to 120-h.p. plough, with four shares for 9-in. furrows, including time lost in tilting at end of furrows, is 315 ft. per minute (about 3½ miles an hour). On those data the following table has been constructed:—

Cost of Electric Ploughing at	3 *cents*	*per kw.-h.*
Depth of furrow in inches ...	8½	10½
Acres per hour	2.25	1.92
Minutes per acre	27	31
Kilowatt-hours per acre ...	19.2	23.2
Cost of electricity per acre, in cents	57.6	69.6
Wages per acre of three men, in cents	20	24.9
Total cost of ploughing per acre, in cents	77.6	94.5

Against such low figures as these other prime movers, as engines driven by steam, gasoline, coal, oil or gas, compete very unfavourably. In the case of steam power, if coal be reckoned at 6.50 dols. per ton, the cost of a 6-h.p. steam plant, including all expenses, with interest, depreciation and repairs, for 500 hours' service per year will be 18.68 cents per horse-power hour, and a 10-h.p. plant approximately 13 cents per horse-power hour. Steam power on a farm is not economical, but if gasoline or oil engines are used these figures can be much reduced. With gasoline, the 6-h.p. plant for the same output of power will be only 13 cents, and with the larger size the cost is reduced to 10 cents. If the consumption of gasoline per horse-power hour be taken at ⅛ gallon, and the cost at 30 cents, and coal oil at 15 cents, there is a saving of some 60 dols. a year on the gasoline plant of the same size. Expressed in kilowatt-hours:—

The estimated cost per kilowatt-hour for 6-h.p. gasoline engine and storage battery = 22.8 cents.

The estimated cost per kilowatt-hour for 6-h.p. oil engine and storage battery = 21.4 cents.

Estimates are suggestive but not very accurate, since local circumstances affect prices very materially. The cost and consumption of fuel are items that are variable in any case, and trade fluctuations will influence the given results in a marked degree. The two most encouraging factors are, first, the care and eagerness of the Canadian Government to supply reliable information to intending settlers, a class likely to be increased after the war; and, secondly, the frequency with which the "exhaust" of a gas engine is heard in the Western prairies, a welcome sign of invested capital, enhanced prosperity and adventurous enterprise.

* Report on Small Water Powers. By A. M. Beale, B.Sc. Water Resources Paper No. 12. Ottawa: Government Printing Bureau, 1915.

THE ARRANGEMENT OF MACHINE SHOPS.—No. XV.

By JOSEPH HORNER.

THE plan views, Figs. 112 and 113, on pages 30 and 31, represent a machine shop of the Chicago, Burlington and Quincy Railroad Company, at Havelock, Nebraska, built by Messrs. Westinghouse, Church, Kerr and Co., of New York. Many of the machines shown are recent additions to the plant. This is a shop arrangement in which the actual growth may be observed, an expansion previously provided for in the building, so avoiding the necessity of extending the buildings lengthwise or laterally. And even after the installation of the new machine tools, room yet remains to introduce others at some later period.

The systematic arrangements which are apparent in this mammoth building are typical of those of a good many works which have been built and laid out in recent years. Immense areas—parallel and rectangular, without obstructions, and with ample spaces left for the handling of articles of work adjacent to the machines where they are tooled, and with room for the introduction of new machines as the exigencies of a growing manufacture call for them. All the new railway shops seem to be designed substantially alike. But, then, they are planned under the most favourable circumstances, in youthful townships where spaces are ample, and having the experience of the earlier shops to serve as beacon lights to warn them what to avoid.

The two plans represent conjointly one vast shop, the left-hand end of which commences at the left of Fig. 112, whence the shop is continued as far as the centre of the building, the other moiety being illustrated in the second drawing, Fig. 113, and completed at the right hand. The centre line of the building on Fig. 112 renders the relation of the two clear. The rolled joists seen in plan indicate that the building is divided into three great bays, the

lowest and widest bay is served by two rail tracks of standard gauge, and the next bay by one track. The machine tools occupy the two upper bays. The lowest one is an erecting shop, with fitters' benches ranged along the whole length of the wall, as seen in both drawings. Benches also occupy nearly the entire wall spaces elsewhere. The lengths allowed for each bench are 5 ft. 10 in., or 6 ft. The tool-room, drawing store, and foreman's office occupy the centre of the building, so that the details of these are divided between the two drawings.

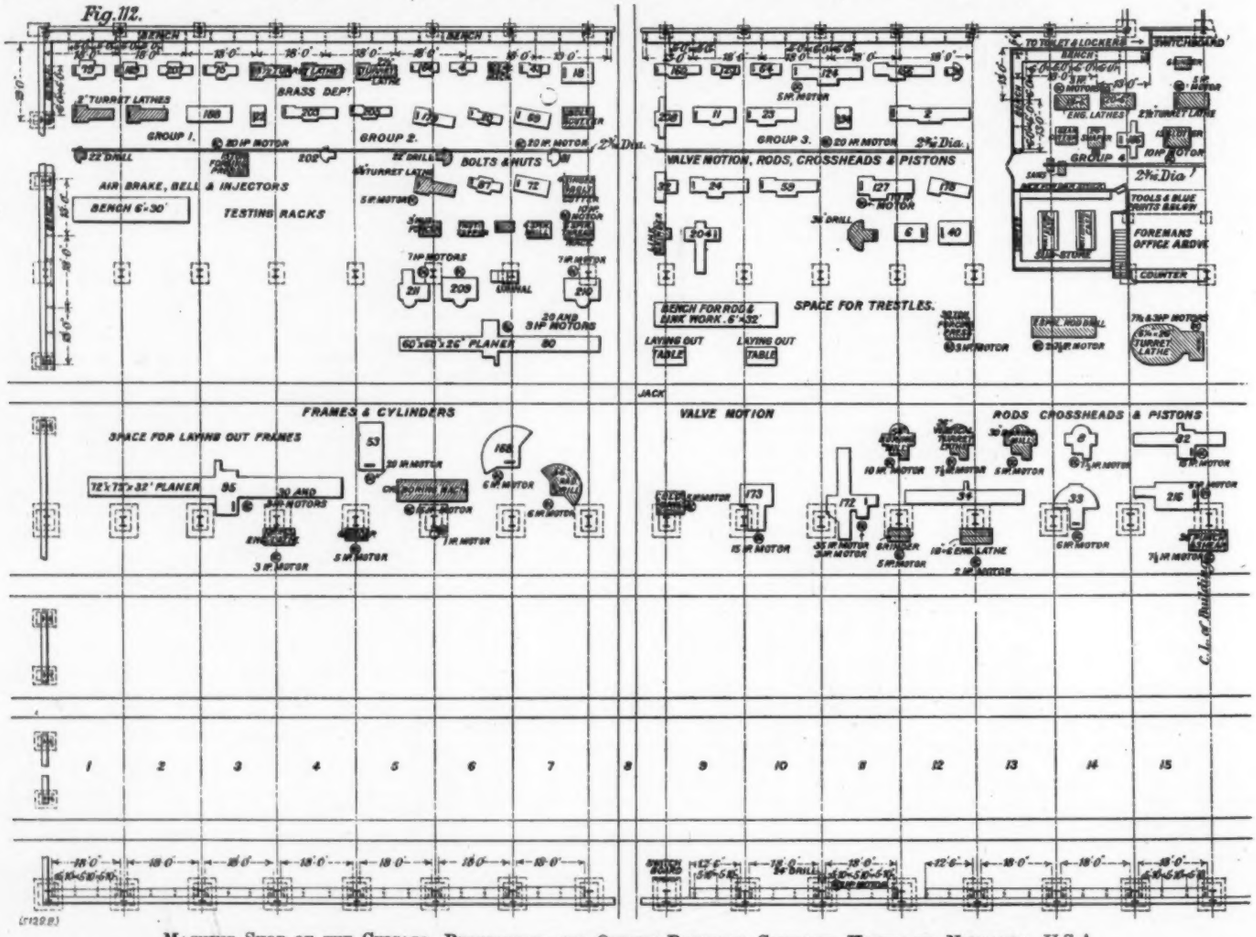
Entering the shop at the top right-hand end, Fig. 113, a large group of lathes and miscellaneous machines is seen, driven from a shaft by a 20-h.p. alternating-current motor. Most of these lathes are ranged parallel with the benches, leaving a clear gangway of about 5 ft. The largest are of 12-in. centres—24-in. swing. Several drilling machines, a shaper, a slotter, and a planer, with the benches, complete the equipment required for a miscellaneous kind of work. In the bay below, adjacent, wheels, axles, and tyres are dealt with in one group of machines, and again wheels and axles in another group. The latter comprises some new machines, the requirements for wheels and axles having outgrown the capacities of the machine tools previously laid down for their manufacture. The new machines are a quartering machine, a vertical boring mill, and a steel tyre car-wheel lathe. Most of the motors are of direct-current type in these departments, and several are very powerful, the 90-in. lathe taking one of 50 h.p. This also, with some others, has two motors, the main one for driving, the auxiliary one for travelling the rest, or the head, as the case may be. Adjacent to these departments is a large lye vat for cleaning grease from iron and steel. It is served by two jib cranes of 20-ft. radius.

Advancing through the shop, Fig. 113, a large area is occupied with rail tracks where wheels on their axles are stocked, and beyond that, past a rail track that crosses the shop, lies the tinsmiths' and pipe-workers' department, this occupying an area in the upper bay. It is flanked on the right-hand with two long racks to carry pipe fittings, and has a number of benches ranged along the upper and left-hand sides. The tools comprise pipe machines, pipe-bending machines, shears, a press, a punch, a brazing furnace and forges, with a blower—motor-driven. Large areas permit of the ready manipulation of the pipes. Located at the lower end of the pipe shop are two boring mills, one being a 96-in. mill driven by a direct-current motor of 15 h.p., the other a 54-in. mill with a 7½-h.p. motor. Beyond, and flanking the lower side of the tool-room, are a cylinder boring machine, a 42-in. planing machine, and a 36-in. turret lathe, each with its individual motor. Large gangways, 15 ft. to 16 ft. wide, adjacent, afford ample room for stacking work that is being turned out by these machines. The machines are flanked by the tracks on the other side.

On the lower side of these tracks a large department is occupied with the production of driving-boxes, shoes and wedges. The majority of the tools here are new, and each has its own motor. The supplementary machines include a two-spindle drill, planers, a boring mill, a grinder, a lathe, and a 50-ton forcing press, which is served by a jib crane of 20 ft. radius. A furnace for melting babbitt metal is located near the babbitting table. Both alternating and direct-current motors are used here. The boring mill and the slotter are served by one crane of 20 ft. radius. An aisle which crosses the shop bounds this department on the left. On the other side a very large area is occupied with the work of rods, crossheads and pistons, the arrangements for which extend over both drawings, as do also those of the tool-room, the tool stores, with the foreman's office, all being located in the upper area of the building.

A considerable number of new tools occupy the department in which rods, crossheads and pistons are prepared. A 36-in. punching and shearing machine, which is repeated in both drawings, being located on the centre line of the building, is a landmark to connect the two drawings. The new tools include, besides vertical boring mills, a vertical turret lathe, an engine lathe, and a grinder. There are two 12-ft. planers in this department, and a large horizontal milling machine, so that a good deal of gang or continuous tooling can be done on rods and crossheads, both by planing and milling. The horizontal milling machine takes 35 h.p., while the big planers take 15 h.p. each, and a large lathe of 12-in. centres only 8 h.p.

Fig. 112.



MACHINE SHOP OF THE CHICAGO, BURLINGTON AND QUINCY RAILROAD COMPANY, HAVELOCK, NEBRASKA, U.S.A.
BUILT BY MESSRS. WESTINGHOUSE, CHURCH, KERR AND CO., NEW YORK.

The tool-room, which occupies portions of both drawings, but in lengths which are unequal, affords an instructive study in its machine equipment. It is not the place for highly specialised machines beyond the special grinding machines for dealing with tool angles, with drills, cutters and dies. There are two universal grinders and one universal milling machine, which cover a large range of general utilities, and also a surface grinder and a plain milling machine. There are a number of standard engine lathes and a turret lathe.

The operations that are performed in the tool-room are not of a highly repetitive character, as they are in the great workshop which it serves. It is, therefore, a small typical general shop enshrined in the greater building. Another feature is that no large interspaces are required for stacking and handling the products. The gangways and distances between the machines seldom exceed 4 ft. to 5 ft., the articles handled being mostly of small dimensions such as can be carried to, and fitted on, the numerous

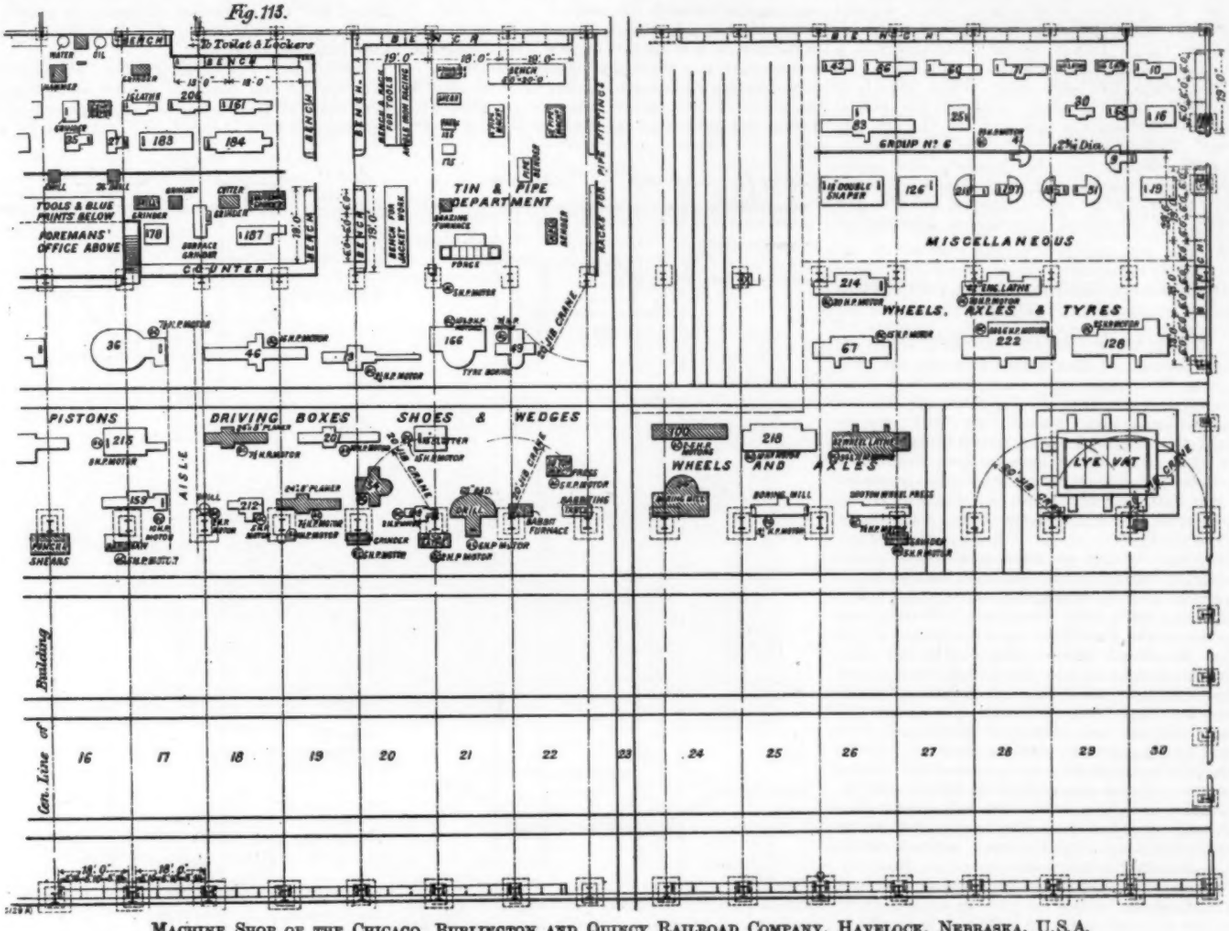
benches that occupy the sides of the room. Also the machine tools are of a widely representative character, because the room is self-contained and independent of the outside shop. They include lathes, various grinders, drills, a gear cutter, a shaper, a slotter, a milling machine, a centring machine, saws, a hammer, an arbor press, and a furnace with tanks for water and for oil. All kinds of small tools for cutting appliances, gauges for measurement, templets, jigs and fixtures, dies, screws, pins required for these fittings, &c., are produced by the

Beyond this room a very large area is occupied with the work on rods, crossheads and pistons, being about as large as that just now noticed on the lower side of the rail track. Adjacent to both areas and in continuation of the same are the spaces which are given up to the valve motions.

In the upper area, in which rods, crossheads and pistons are prepared, the machine tools are of smaller dimensions than are those in the lower one, and therefore, with the exception of three engine lathes and a forcing press, all receive power from a

Beyond the transverse tracks the upper part of the shop is occupied with the brass department, which is always a large one in a locomotive works. Here the engine lathes are outnumbered by the turret lathes, and of these, those which deal with chuck work outnumber those for bar work, the latter being set at an angle. Other tools are a centring machine, two bolt cutters, and a wet grinder. All these are driven from shafting in two groups, with motors of 20 h.p. Benches are ranged along next the walls. One of the shafts which drives

Fig. 113.



MACHINE SHOP OF THE CHICAGO, BURLINGTON AND QUINCY RAILROAD COMPANY, HAVELOCK, NEBRASKA, U.S.A.
BUILT BY MESSRS. WESTINGHOUSE, CHURCH, KERR AND CO., NEW YORK.

TABLE OF REFERENCES.

2. 24-in. by 20-ft. engine lathe.
4. 16-in engine lathe.
6. 12-in. slotter.
8. 51-in. boring mill.
9. 36-in. drill.
10. 24-in. by 10-ft. engine lathe.
11. 24-in. by 10-ft. engine lathe.
12. 12-in. slotter.
13. Cylinder boring machine.
18. 2¼-in. double-head bolt cutter.
19. 13-in. slotter.
20. Turret lathe.
22. Wet grinder.
23. 36-in. engine lathe.
24. 36-in. engine lathe.
25. Key seater.
27. Plain miller.
30. 16-in. by 6-ft. engine lathe.
32. Plain miller.
33. 60-in. radial drill.
34. 40-in. by 12-ft. planer.
35. 30-in. vertical drill.
36. 36-in. turret lathe.
40. 13-in slotter.
41. 24-in. drill.
42. 16-in. engine lathe.
43. 16-in. engine lathe.
46. 42-in. planer.
49. 54-in. boring mill.
51. 36-in drill.
53. 24-in. slotter.
59. 36-in. by 13-ft. engine lathe.
60. 24-in. by 12-ft. engine lathe.
64. 16-in. engine lathe.
66. Radial drill.
67. 60-in. wheel lathe.
68. 16-in. engine lathe.
69. 2-in. by 24-in. turret lathe.
71. 24-in. by 12-in. engine lathe.
72. 2-in. by 24-in. turret lathe.
75. Brass turret lathe.
78. Tool grinder.
79. 20-in. by 7-ft. turret lathe.
80. 60-in. by 60-in. by 26-ft. planer.
82. 42-in. by 12-ft. planer.
83. 42-in. by 12-ft. planer.
86. 24-in. by 12-ft. engine lathe.
87. Turret lathe.
91. 20-in. drill.
94. Wet grinder.
95. 72-in. by 72-in. by 32-ft. planer.
98. 38-in. band saw.
100. Quartering machine.
122. 14-in. by 6-ft. engine lathe.
124. 30-in. by 16-ft. engine lathe.
126. 18-in. single-head shaper.
127. 38-in. by 14-ft. engine lathe.
128. 90-in. wheel lathe.
156. 24-in. by 14-ft. engine lathe.
160. 18-in. by 10-ft. engine lathe.
161. 18-in. by 12-ft. engine lathe.
164. 16-in. by 6-ft. engine lathe.
166. 96-in. boring mill.
168. 72-in. radial drill.
169. 20-in. turret lathe.
172. Horizontal milling machine.
173. Vertical milling machine.
178. 3-in. by 36-in. turret lathe.
179. 2-in. by 24-in. turret lathe.
187. Universal grinder.
188. Four-spindle drill.
195. 34-in. drill.
196. 42-in. engine lathe.
197. 84-in. drill.
203. 24-in. by 14-ft. engine lathe.
204. Oscillating surface grinder.
205. 18-in. by 8-ft. engine lathe.
206. 18-in. by 8-ft. engine lathe.
207. 20-in. turret lathe.
208. Plain miller.
209. 42-in. boring mill.
210. 42-in. boring mill.
211. 36-in. boring mill.
213. 4-in. pipe machine.
214. 42-in. engine lathe.
216. 24-in. by 12-ft. engine lathe.
218. 600-ton hydraulic press.
219. 30-in. drill.
222. 90-in. wheel lathe.

all-round skilled mechanics in this room. With the exception of three lathes and a slotter, which have direct-current individual motors, the machines are driven from shafting in two groups from 3-h.p. and 15-h.p. motors. On the lower side of this room the long counters are ranged, with three openings through which tools are handed out and returned to store. The tool store and that for blue prints occupy a large floor area, over which is built the foreman's office, having stairs at each end, and commanding a view of the entire building. A sub-store contains the expensive materials that are kept in the tool-room.

shaft that is driven by a 20-h.p. motor. Lathes comprise the greater part of the tools here. The angular position of the turret lathe may be observed, so placed in order to permit bars passed through the hollow spindle from the rear to clear the lathe adjacent. There is a wet grinder for the rods, a link grinder, an oscillating surface grinder, two plain milling machines, two drills, and two slotters. Benches occupy the width next the wall along the upper side of the shop. A bench on the lower side is used for fitting the link motions together, and there are two laying-off tables adjacent. The valve motion department is bounded by a track that crosses the shop.

the right-hand group of machines in the brass department serves also another group of machines for making bolts and nuts, which are ranged on the opposite side of the shaft. These—that is, the shaft-driven tools—include two drills, two turret lathes set diagonally, a bolt cutter, a nut forcer, a nut tapper, a centring machine, and a stay-bolt drilling machine. The remainder of the tools here are provided with their own motors. They include a turret lathe and a stud and stay bolt threading and reducing machine. A large area situated beyond is hardly occupied as yet. Air brake work and that of bells and injectors is done here, work to which

the brass department is contributory, and also that of some boring mills located below the bolt and nut shop. The fitting is done on benches next the wall, and on another bench 30 ft. long by 6 ft. wide to the right hand. Testing racks occupy a small portion of the area.

The last portion of the building is devoted to the work of frames and cylinders. It is occupied by a few large machines separately motor-driven, and a space where the frames are laid out. The largest machine is a frame-plate planer, having 32 ft. of table travel and taking a 30-h.p. motor for the main drive. A big slotter, with a 24-in. stroke, requires a 20-h.p. motor to drive it. A cylinder-boring machine has a 15-h.p. motor. Radial drills, a grinder and a lathe complete the equipment.

These shops, like some others which have been illustrated, show in sharp contrast the radical difference between the new and the old arrangements. Instead of the turnery, the planer department, the drilling shop, the grindery, and so on, machines representative of every class are grouped among those of other classes, selected and arranged around the specialised branches of manufacture done.

THE HARLEM RIVER SUBWAY TUNNEL, NEW YORK.

By FRANK W. SKINNER, M.Am.Soc.C.E.

THE borough of Manhattan, formerly the city of New York, and now the central and most populous and commercially important of the five boroughs comprising greater New York city is located on a long and narrow island at the head of New York Bay. It lies between Long Island and the State of New Jersey, from which it is separated by the East and the North, or Hudson, Rivers respectively, the northern end being bounded by the Harlem River.

Conditions.—There are short-span bridges across the Harlem River, four to eight-track cantilever and suspension bridges—among the longest spans in the world—and the 1,000-ft. four-track Hell Gate arch span across the East River, and no bridges as yet across the North River. The North and East rivers are each crossed by eight single-track tunnel tubes for electric cars. There are also three tunnels under the East River for large gas mains. All except the last have cast-iron linings and were driven by the pneumatic shield method.

The first rapid-transit subway crosses the Harlem River in a double-track high-level tunnel, and its extensions, now being completed, will cross it in a four-track high-level tunnel constructed under difficult conditions by an unusual method, which will be described in this article.

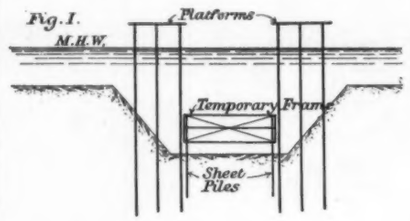
This new tunnel, at the foot of Lexington-avenue and 135th-street, crosses the river at a point where it is 600 ft. wide between bulkhead lines and is 26 ft. deep at low tide. The bottom penetrated is chiefly composed of soft mud, and as there is important navigation that must not be interrupted it is not permissible to obstruct the channel, and the problem of constructing the tunnel at the highest elevation clearing navigation was a difficult one.

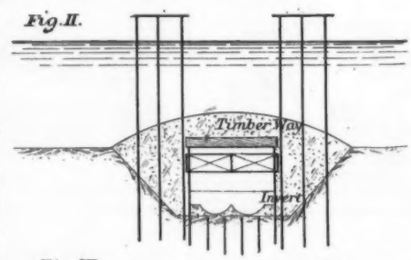
Open cofferdams or pneumatic caissons containing sections of the tunnel were inadmissible on account of the obstructions involved; ordinary tunnelling was impossible with the soft ground and thin roof; the depth of water and the required elevation precluded the preliminary deposition of a clay blanket on the bottom to form a reliable roof; and there was not throughout sufficient depth or bearing capacity of soil for the use of the pneumatic shield method. The principal alternatives were the freezing process, which is very slow, costly and uncertain; the pneumatic trench process; and some modification of the sunken tube process.

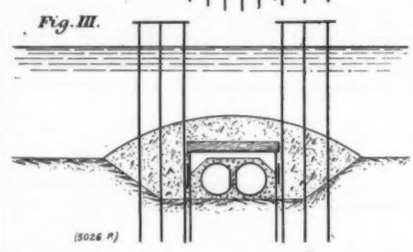
Rival Scheme.—Strong efforts were made to secure the adoption for this construction of the pneumatic-trench method very successfully used in 1903 for the construction near by of the double-track tunnel in which the first subway crosses the Harlem River under similar conditions at a point where it is 300 ft. wide and 28 ft. deep. This tunnel has a segmental cast-iron lining made of two intersecting 15-ft. tubes 12½ ft. apart on centres, embedded in a solid mass of concrete 31½ ft. wide, 19½ ft. high, and about 28½ ft. in the clear below high tide, which was built in a dredged trench with a submerged airtight roof, by a method designed and executed by D. D. McBean.

The tunnel, 640 ft. long, was built in two nearly equal successive sections extending from the opposite shores to the centre of the river, and constructed in submerged covered cofferdams which involved only the permissible obstruction of half the width of the navigable channel at once. The annexed sketches, Figs. I to VII, will aid in explaining the methods adopted.

On the west side of the river a trench 50 ft. wide at the bottom was dredged to 10 ft. above subgrade, and on each side there was driven a triple row of piles, forming two working platforms 38 ft. apart in the clear. In the trench four rows of piles were driven and cut off at the level of the top of the





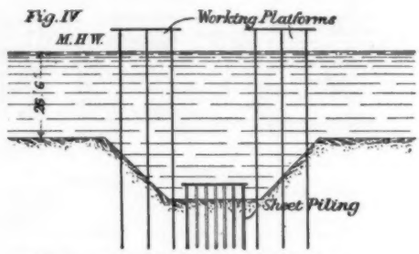


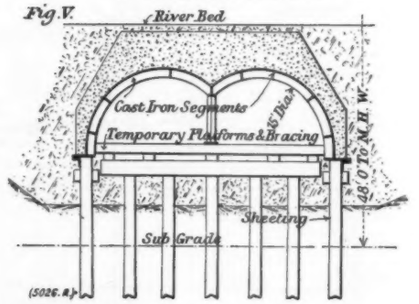
finished concrete structure. A wooden framework consisting of trusses and heavy transverse braces (see Fig. I) was sunk to rest on and enclose the tops of the piles and to serve as bracing for rows of heavy wooden sheet piles driven against the sides of the framework to form the longitudinal walls of the cofferdam.

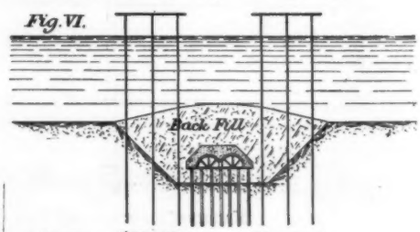
The ends of the cofferdams were closed by heavy timber bulkheads, and a solid timber roof platform 40 in. thick (Fig. II) was sunk to rest on the sheet piles and bulkheads, taking bearing on the vertical flanges of T-bar shoes, which gained into the timber and forced tight joints. The trench was back-filled, the water was pumped out of the cofferdam chamber, air pressure was applied, the bottom excavated to subgrade, the piles cut off to form foundations for the tunnel, the invert concrete laid, the cast-iron lining assembled, and the remainder of the concrete placed over and around it (Fig. III).

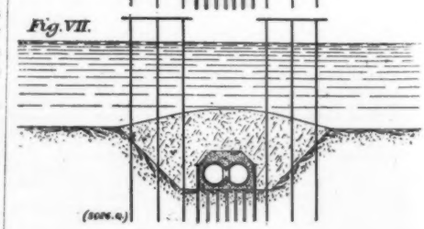
Some modifications were developed for the construction of the eastern section of the tunnel, which was built in three parts, each about 90 ft. long. The working platforms were removed from the west to the east side of the river, shifting navigation to correspond, the trench was dredged to within 5 ft. of subgrade, five rows of piles were driven in it and cut off a little above the bottom of the trench, a horizontal timber platform was sunk to rest on the tops of the piles, wooden sheet pile walls were driven on each side of the trench, 38½ ft. apart in the clear and cut off accurately at the elevation of the centre line of the tunnel, and the assembled upper halves of the tunnel tubes were floated out and sunk to position, being supported by extended horizontal flanges at the springing lines, and thus forming the roof of a pneumatic chamber (see Figs. IV, V and VI). The chamber was pumped out, pneumatic pressure applied, the excavation completed, interior piles cut off at subgrade, concrete invert laid, the remainder of the cast-iron shell segments assembled, concrete deposited under water over the top and sides of the tunnel, and the trench back-filled over it (see Fig. VII). The work was satisfactorily completed, and the contractor subsequently offered to build similar structures in New York for a price of 1,000 dols. per lineal foot.

Description of Four-Track Sunken Tube Tunnel.—Very careful and complete studies and estimates were made by the contractors and engineers of the pneumatic-trench method and other types and









methods of tunnel construction for the Lexington-avenue crossing, and eventually the sunken tube method was adopted on considerations of safety, rapidity, economy and convenience, and it was built by a modification of the design and method first used by Olaf Hoff, M.Am.Soc.C.E., in 1900, for the construction of the double-track railroad tunnel, 80 ft. deep and 2,625 ft. long, under the Detroit River at Detroit, Mich.

The alignment of the tunnel (see Figs. 1 to 14 on Plate II), 1,080 ft. long, is tangent except for 40 ft. of 2½ deg. curve at one end, and is graded 3 per cent. from both ends to a sump in the middle, subgrade being at a maximum depth of 57 ft. below mean high tide. The structure consists of a 24½ ft. by 78 ft. rectangular mass of concrete enclosing four

flattened intersecting steel tubes, 19 ft. in diameter and 17 ft. apart on centres, which are connected by 24½ ft. by 76 ft. vertical transverse steel plate diaphragms 15 ft. 7 in. apart. An end view, plan and sections of one group of tubes are given in Figs. 20 to 23, Plate V.

The tubes are made of ⅜-in. plates about 8 ft. wide, with riveted lap joints. The longitudinal joints are double-riveted and the transverse joints are single-riveted through outside circular flange angles. At every second joint these flange angles are 3½ in. by 3 in., and serve as connections for the ½-in. diaphragm plates, which project 2 ft. 3 in., 3 ft. 3 in., and 3 ft. respectively beyond the lower, upper and outer sides of the tubes. The transverse tube joints intermediate of the diaphragms are stiffened by 4-in. by 3-in. angles. The diaphragms are stiffened by flange angles on the outer edges. Between the diaphragms the vertical walls, 2 ft. apart, of the flattened sides of the adjacent tubes are connected by horizontal tie-bolts that also serve to secure U-shape anchors for the concrete lining (see Fig. 20).

The tubes were completely riveted on shore in five nearly equal four-tube sections, these being eventually connected together by joints bolted up under water. Views of the tubes in course of construction at the contractors' yard are shown by the photographs reproduced in Figs. 15 and 16 on Plate III.

Transverse 4-ft. by 9-ft. passages with watertight steel plate walls were made between adjacent tubes. The ends of adjacent tube sections were made with exterior angle flanges and interior Z-bar flanges, providing strong, tight joints easily bolted under water by divers. The outstanding legs of the angle flanges were connected by ⅞-in. bolts, 16 in. apart, and the cylindrically curved outstanding flanges of the Z-bars were punched to receive bolts through the connecting plates. Near the middle of the river a steel plate sump, 7½ ft. wide and 25 ft. long, with a domed bottom, was provided under each pair of tracks. Each tube in one of the end sections was provided with a flanged 3-ft. vertical steel air shaft, 4 ft. long, riveted to the upper side to provide connections for giving shafts access to the tubes for pumping, concreting, &c.

The tubes were surrounded by a solid mass of 1 : 3 : 6 Portland cement concrete enclosed between the vertical diaphragms and longitudinal vertical wooden walls connecting their outer edges. They were lined with 1 : 2 : 4 concrete about 12 in. in minimum thickness, which was reinforced by 1-in. square longitudinal and transverse rods. Refuge niches, 6 in. deep, were formed about 20 ft. apart in the vertical walls; boxes containing electric wires were built on both sides of the tracks, and wherever necessary terra-cotta drain pipes were embedded in the concrete inverts under track centres. Each linear foot of the completed structure contains 5,800 lb. of steel, 36 yards of exterior and 11.6 yards of interior concrete.

Tunnel Excavation.—For the full length of the tunnel there was excavated in the river bed a trench 80 ft. wide on the bottom, with an average depth of about 32 ft., and having the sides sloped to the natural angle of 1 : 2. The bottom, consisting of sand, clay and gravel, was overlaid with 10 ft. to 15 ft. of soft mud, and was in places so hard that it was with difficulty removed by a 5-yard clam-shell bucket weighing 5 tons empty. The maximum depth of the trench was 50 ft. at the banks, and from it 275,000 yards of earth was dredged in 18 months by a force of about 10 men. A photograph of a 5-yard clam-shell dredger is reproduced in Fig. 17, annexed.

Besides the earth dredging, about 2,000 yards of rock on the north side of the river was blasted and removed to an average depth of about 38 ft. by 10 men in 6 months. For this work a steam machine, mounted in a pile-driver frame, as shown in Fig. 19, Plate IV, drilled 4-in. holes to a maximum depth of 60 ft., 5 ft. below subgrade, to insure against projecting summits of rock. The holes were spaced 5 ft. apart in both directions, were charged by divers with 1 lb. to 1½ lb. of 60 per cent. or 70 per cent. dynamite, and broke the rock into pieces small enough to be removed by the 7-yard dipper-dredge bucket used. A view of this dredger is given in Fig. 18 on Plate IV, while Fig. 20 on the same Plate shows one of the lumps of rock brought up. All the soil was loaded into 500-yard scows, towed over 30 miles to sea, and dumped.

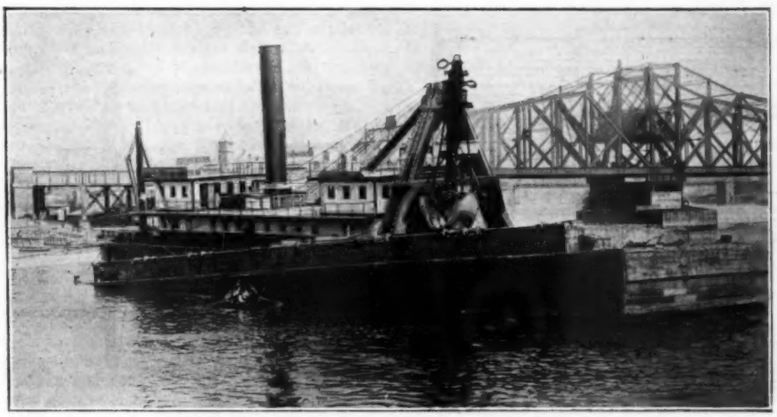


FIG. 17. DREDGER WITH 5-YARD CLAM SHELL BUCKET.

Constructing the Quadruple Steel Tubes.—The structural steel for the tubes was fabricated at the Ambridge shops, near Pittsburgh, and delivered by lighter to the contractors' waterfront yard on the Harlem River, about a mile from the tunnel site. The steel was stored on one side of the 130 ft. by 250 ft. slip, which was commanded by derricks, and a locomotive crane with a 50-ft. 20-ton boom, as seen in Fig. 16, Plate III.

Part of the plates and angles were riveted up on shore and their lower sections were assembled on falsework in the slip, forming cradles, in which the tubes were built. The lower flanges of the transverse diaphragms rested about 1 ft. above high-water level, on four longitudinal lines of pipe caps, 18 ft. apart in the clear. Each section of the tubes required about 80,000 ¾-in. field rivets and 12,000 linear ft. of caulking, this being done by pneumatic tools operated by a total force of about 65 men. This force included 10 to 15 four-man riveting gangs, each of which drove an average of 400 rivets in 8 hours, with a maximum of 522. In order to secure plenty of light for the interior work, alternate crown plates were omitted until the rest of the work was completed. The average time for completely assembling, riveting and caulking one 220-ft. section was 30 working days.

(To be continued.)

THE NATIONAL PHYSICAL LABORATORY IN 1916–17.

(Concluded from page 5.)

Heat. High Temperature Scale and General Work. (Dr. J. A. Harker, F.R.S., Captain A. Blackie, Mr. Ezer Griffiths, M.Sc., Mr. F. H. Schofield, B.A., B.Sc.)—Dr. Harker and Mr. Blackie being engaged on other duties, the heavy routine work (especially optical pyrometer testing) and the research work on high temperature scales, as well as the testing of refractories and confidential investigations, have fallen on Mr. Griffiths and Mr. Schofield. Two optical pyrometers of the polarising (Wanner) type, purchased from the Cambridge Scientific Instrument Company, have been calibrated up to 1,600 deg. C. by comparison with thermo-couples. In the preliminary work a new couple, platinum-platinum with 10 per cent. of rhodium, from Messrs. Johnson and Matthey, was standardised up to 1,550 deg. C., the E.M.F. of the couple being determined at the boiling-points of water, naphthalene, diphenylamine and sulphur, and at the freezing-points of tin, zinc, antimony, silver, gold, copper, nickel, palladium. The last two metals (freezing-points, Ni 1,452 deg. and Pd 1,549 deg. C., according to Day and Sosman on the gas-thermometer scale) caused considerable difficulties. The nickel, obtained in berries of 99.14 per cent. and 99.9 per cent. Ni, was first melted in a blast muffle in a graphite crucible, being covered with graphite powder; the cooling curves, taken by the aid of the couples in their sheaths of Morgan porcelain, gave freezing-points of the two nickel samples all agreeing within 2 deg. C., but about 1,330 deg., *i.e.*, 120 deg. below the normal, 1,452 deg. C. The freezing-point seemed to have been lowered by the absorption of carbon, and the constancy of the observations suggests that the point 1,330 deg. C. may be a fixed one—which would be valuable, as there is at present a long gap between the freezing-points of copper, 1,083 deg., and of nickel; the point is to be further investigated. Attempts to melt nickel in a clay crucible surrounded by a refractory tube through which nitrogen was passed failed because the tubes could not stand the extreme temperatures. Ultimately the nickel was successfully melted by the blowpipe flame, under a layer of borax, in a Juleff crucible, without liner tube, but painted outside with carborundum powder; the borax deeply pitted the crucible, however, and spoiled it for further use.

Cooling curves of sufficient masses of fused palladium being out of the question, the wire method was used. The two arms of the thermo-couple were connected by a short length of palladium wire, 0.5 mm. in thickness; the thermo-couple leads were inserted in a glazed porcelain tube (Fig. 9); this

Fig. 9.

was surrounded by a liner tube of Morgan porcelain (alundum tubes failed) axially fixed in the spiral of graphite or carbon tube of the electric furnace. The arrangement was as in Fig. 10, page 34, except that the glazed tube replaced the inner tube of Fig. 10, and that the furnace was vertical, the pyrometer being absent. The melting palladium bead would drop and break the current; sometimes it seemed to draw the arms of the thermo-couple together without breaking the circuit; hence a small rider of fireclay was fixed near the wire ends over which the short Pd wire was hooked. There were other troubles with breaking liners, but finally a series of melting-points agreeing within ± 1 deg. C. was obtained.

These observations on the thermo-couple completed, its temperature scale was computed. The curve connecting E.M.F. and temperature for platinum alloys was found to be approximately a cubic up to 1,100 deg. C., and above that a parabola; the various formulæ used are merely empirical, however, a law has not been established yet, and the Laboratory relies on its tabulated values. Then followed the observations on the two optical pyrometers (Wanner type) above mentioned. They were sighted on a black-body furnace with the pyrometer in front of it (Fig. 10); five furnaces were used, the furnace

in Fig. 10, a carbon tube, or one of three platinum-wound furnaces for temperatures up to 1,330 deg. The thermo-couple was exposed across the face of a plug in the centre of the furnace, the plug being magnesite on a silica tube for the Pt furnaces, or the base of a very small clay crucible for the highest temperatures. The results of the experiments with the five furnaces agreed well with one another, and from these results, which were subsequently confirmed by melting-point determinations of copper, gold and palladium made with the pyrometer under black-body conditions, the temperature scales of the pyrometers were obtained; experiments with wires of nickel and of platinum were less satisfactory, although hydrogen or nitrogen was passed through the furnace in the former case to prevent oxidation. Fig. 10 shows how the copper wires were mounted in these cases. During the calibration of the pyrometers failures of the liner tubes again caused difficulties; but the Cambridge Scientific Instrument Company presented the Laboratory with some lengths of German porcelain tubes of the highest grade. The temperature scale of the observations can be varied and raised by interposing one or two red absorption glasses between the pyrometer and the furnace mouth. In the verification of the standard total radiation pyrometers a carbon tube

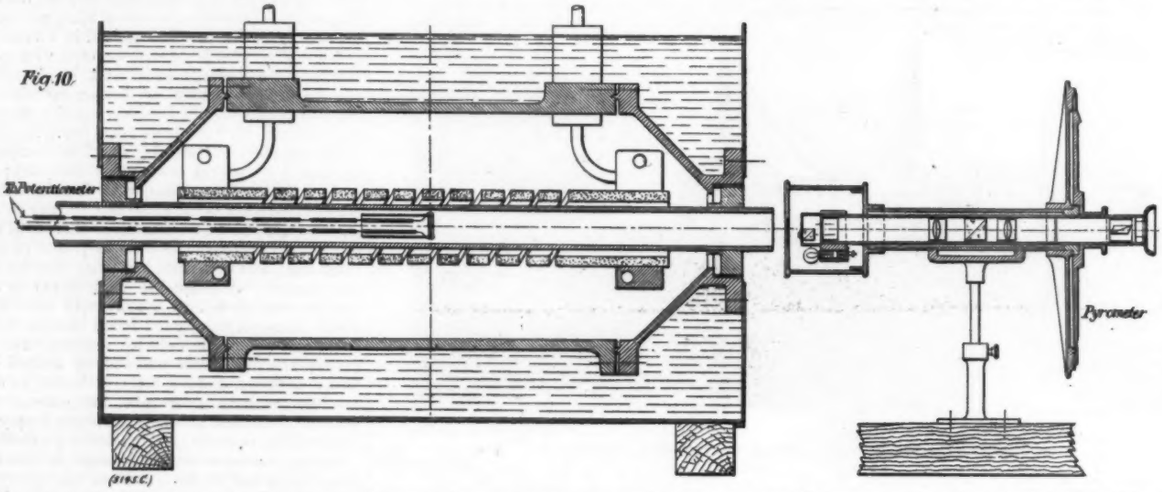


Fig. 10.

wound with nickel-chromium alloy has so far been used; the tape, of 10 mm. width, 1 mm. thick, took 40 amperes and stood 1,100 deg. for a long time, but burnt out after two hours at 1,300 deg. The further work on Féry pyrometers chiefly concerns the use of series of screens for different "apparent" temperatures at constant furnace temperature.

Thermal Conductivity. Refractory Materials.—The research on the relative efficiencies of slag wool, granulated cork and slab cork for cold storage work has been completed; the work being for a private firm, no information is available, unfortunately. The investigation of the thermal conductivity and thermo-physical tests of refractory materials is continued; Mr. Griffiths contributed two papers to the discussions on high-temperature furnaces and refractory materials before the Faraday Society in their November and December meetings. We noticed these papers at some length in our issues of November 17 (page 489) and December 29 (page 645), 1916.

Thermometer Testing. (Captain G. W. C. Kaye, D.Sc. (on active service), Mr. W. F. Higgins, B.Sc., Mr. W. Hugo.)—The tests of mercury and spirit thermometers mentioned last year have been continued. Of the 461 precision thermometers sent in 265 were high-range instruments. The examination of makers' standards has in several instances resulted in improvement in the quality of instruments subsequently submitted, but further advantage should be taken of the facilities offered by the Laboratory. The number of Kew class meteorological thermometers decreased by 300 to 3,164. The number of clinical thermometers rose from 16,137 (1915) to 24,272, the largest number dealt with since this testing was transferred from Kew to the Laboratory; the quality of certain clinical thermometers submitted last year left much to be desired, but there is some improvement in this respect. The increase in the work is partly due to tests for the Admiralty and Navy, and arrangements are made for further increasing the capacity of the division.

Optics. (Mr. T. Smith, B.A., Mr. J. Guild, Dr. J. S. Anderson, Miss A. B. Dale, Mr. R. J. Trump.)—The optics division was also overburdened with work which had to be undertaken by a staff depleted by the loss of Mr. R. W. Cheshire (who joined a manufacturing firm) and of Mr. D. W. H. Bell (in the Army). The number of binoculars and telescopes tested further increased from 17,656 to 18,522, which is more than double the number of two years ago, but this number does not represent anything like the actual increase in work, as the Admiralty called for new tests and special work, taxing the time of the staff to the utmost limits. The determination of the refraction and dispersion of glass also caused much work. The improvements effected in obtaining a bright hydrogen spectrum for this purpose were noticed in our account of the Optical Society's Exhibition of last December. The Pulfrich refractometer (Zeiss instrument), which is used in these tests, Mr. Smith points out, is very convenient and sufficiently accurate for all commercial purposes, when the absolute value of the refractive index and of the dispersion ought to be correct within ± 0.0001 or ± 0.0002 or 3; the errors can be adjusted with the aid of the apparatus of the Laboratory. But the Pulfrich refractometer is essentially a comparative (not an absolute) instrument. A check can be obtained with the aid of prisms, which can be measured on a spectrometer as well as on a refractometer; these specimens are of glass, however, and the checks consist of measurements of indices for water and quartz. For the higher accuracy of dispersion now required the Pulfrich refractometer, as at present made, is not suitable, and the whole problem is now under consideration. As regards the refraction and dispersion of irregular and lenticular pieces of glass, Mr. Cheshire described a testing method in the *Philosophical Magazine* of last October; a more compact form of this instrument is now used. A new type of spherometer, the micrometer of which can be set to 0.1 μ, has also been evolved, but about this instrument and signalling apparatus no information is available at present. Nor are particulars given as to the optical method of determining the rate of settling of buildings in cases where mechanical apparatus are inadmissible. A "Table of Constructional Data for Small Telescope Objectives" was published (by Messrs. Harrison and Sons) in 1915, and an additional second volume, likewise compiled by Mr. T. Smith and Mr. Cheshire, has since been published; these extensive and useful tables show the effect of varying the optical position of the glasses employed and the changes in lens curvature required to compensate for them. A full investigation has also been made of the second order aberrations of triple-cemented telescope objectives (as compared with double objectives), and the calculations for cemented objectives of any number of elements can now be performed with the aid simply of quadratic equations. On the "Determination of Coma"—the term comprises aberrations generally, and is particularly applied to the lateral aberration of oblique rays, whilst spherical aberration concerns cases in which the object is situated on the axis of the instrument—Mr. T. Smith read a paper before the Physical Society a few weeks ago, on June 22, while Mr. J. Guild dealt on the same occasion with "Chromatic Parallax." The subjects are of great importance; Mr. Guild especially pointed to the difficulties which this chromatic aberration causes in making measurements in certain parts of the spectrum, and described means of meeting these difficulties.

As in former years, specifications for optical instruments have been drawn up for the Admiralty, and advice has been given to public departments and private firms. A comprehensive scheme for researches into optical instruments at the Laboratory, in connection with the optical manufactures of the country, has been drawn up and is now under discussion.

Radium and X-Ray Work. (Dr. Kaye, Mr. Higgins, Miss W. E. Donnelly.)—The 31 radium salt samples tested during the year represented an insurance value of 8,000*l.*; this number shows a further, not unexpected, decrease (47 samples last year), and the equipment of the division remains unchanged. The tests are made by means of γ-rays, and the standards are always kept well enclosed; use of emanation is not made, and the contamination of the room with radium is not to be feared therefore. We have already noticed Mr. Higgins' share of work in the study of radium luminous compounds.

Tide Predictions. (Mr. F. J. Selby, M.A., Mr. W. H. H. Brookes.)—In the absence, on active service, of Mr. A. H. Bell, the preparation of the Indian Tide Tables has been carried out by Mr. Brookes and Miss R. M. Rudkin; good progress has already been made with the tides for 1919. The predictions for the Port of Brisbane are being continued, and predictions are also made for the tidal station of Koh Hlak, off the coast of Siam.

Library.—The library has been in charge of Miss E. M. Barker, Mr. R. A. Frazer having joined the aeronautics department of the Laboratory.

Metallurgy and Metallurgical Chemistry. (Superintendent, Dr. W. Rosenhain, F.R.S.; Messrs. J. Murdock, Guy Barr, S. L. Archbutt, W. H. Withey, L. L. Bircumshaw, J. L. Haughton, T. E. Rooney, D. Hanson, E. A. Coad-Pryor, V. H. Stott, and others.)—The department has been very largely occupied in war work of a confidential character. The depleted staff has been supplemented by the engagement of nine women, most of whom were, and are, trained as chemists; they have attended a course of lectures on metallurgy which the superintendent has given to the staff of the Laboratory in general. Women have proved especially useful also in the working of crucibles, muffles, &c.

Equipment.—The additions to the equipment have been slight, apart from the extensions, by the

Office of Works, of the foundry, which is now of twice its original size and provided with an iron bridge. This bridge can be moved about by the crane and placed astride any of the furnaces, and carries, among other devices, the stirring machine for the optical glass furnace to be mentioned below. A novel type of electric resistance furnace for refractories, &c., will also be briefly described. Leads from the alternate-current mains in the foundry have been taken up to the furnace-room of the Wernher building, where a small 5-kw. transformer has been installed. Dr. Rosenhain's very efficient but noisy injector burners, in which a mixture of gas and air under a pressure of 80 lb. per square inch is burnt and temperatures of 1,700 deg. C. can be reached, have been removed to a special part of the foundry. The metal-melting gas furnaces there are now placed in a pit. The vertical tube gradient furnaces for thermal curves have been improved by placing them in steel casings, flanged at the ends and fitted with base and cover plates. A furnace tube of 3 in. diameter is, in this casing, surrounded by 6 in. of insulating material; the heating coil of nichrome is wound on a separate tube, to be pushed over the upper end of the furnace tube, and is removable for rewinding; nitrogen is passed through the furnace while it is being heated, and the life of the nichrome is thus prolonged. In these gradient furnaces the specimen is slowly lowered down the tube or raised from it; this can be done by the aid of electric motors or of magnetic devices driven by contacts from the pendulum of a standard clock. A new device for this purpose consists of an oil tube, the piston of which is weighted and operates through a wire passing over pulleys; a bypath to the oil tube is provided with a valve, by means of which the specimen can be started from any position without altering the adjustment of the needle valve which determines the rate of movement. The muffles of ordinary fireclay having been found liable to crack, muffles of various dimensions are now made in the department of carborundum; they have stood the test of several months' use very well.

Alloys Research.—Aluminium alloys for aircraft have claimed most attention, and important reports have been made to the Advisory Committee on Aeronautics and to the Admiralty and Army. Dr. Rosenhain represents the Laboratory on the Sub-Committee for Alloys. The continued work for the Alloys Research Committee of the Institution of Mechanical Engineers chiefly concerns light alloys, binary and ternary, of aluminium with zinc, copper, iron, silicon, and magnesium and their equilibria. Publication of the important results is not deemed advisable at present; a confidential demonstration took place in November and helped the Laboratory to a considerable increase in the grant for building and equipment from the Research Department of the Advisory Council. The large electric annealing furnace in the rolling mill, which has amply justified its erection, is provided with end stoppers, more than 1 ft. in diameter; heating coils are attached to the inner faces of these stoppers to obviate losses by radiation; the coils are nichrome tape, up to ⅛ in. in thickness.

Steel; Standardised Steel Samples.—For the continuation of the work on permanent magnet steels for magnetos, carried out on behalf of the Institution of Electrical Engineers, Messrs. Firth and Sons, of Sheffield, and Dr. W. H. Hatfield, of the Brown-Firth Research Laboratories, have prepared some special tungsten carbon steels. The Institution of Automobile Engineers has also submitted a good deal of work (heating and cooling curves taken by means of Dr. Rosenhain's chronograph), and fractures of boiler plates have been studied for the Admiralty; they illustrate the dangers of annealing at temperatures below the critical point of steel. A research on the hardening of steel gauges of special steels has recently been started. As regards standardised steel drillings, the Iron and Steel Institute and the Laboratory are co-operating for the purpose of issuing such standard samples to steel works chemists as is the practice of the United States Bureau of Standards. There are many outstanding discrepancies in steel analysis which call for such a measure, and the present dearth of fully trained metallurgical chemists makes the question urgent.

Other Metals.—The miscellaneous work on other metals called mainly for the study of economical alloy substitutes wanted by the Ministry of Munitions and other departments; many suitable substitutes have been found, and success has been realised particularly in connection with alloys for fuses and cupro-nickel.

Optical Glass.—This research, in which the Laboratory is collaborating with the Institute of Chemistry and other bodies, has made considerable progress, in the first instance with refractories for optical glass melting. Pots have been made of one material throughout or have been provided with more expensive linings; improved methods of melting and stirring have also been devised. For burning refractories a special type of electric furnace has been evolved. After successful experiments with a furnace 2½ in. in diameter, one of 7 in. diameter was constructed, and a larger furnace is now being made. In these furnaces heat is generated by contact resistance between specially shaped graphite parts, and an endeavour is being made to substitute pressed carbon similar to that used in arc lamp electrodes, as the latter can be obtained in this country; valuable help has been given in this direction by the carbon department of the General Electric Company. The gas-fired regenerative furnace is working excellently in the foundry. It is fitted with five horizontal rows, each of four regenerator tubes of carborundum, the colder ends of the tubes being made of silica. The original magnesite lining of the furnace has been replaced by a lining of crude zirconia bricks, the use of which allows of an appreciable saving in gas consumption. The furnace is now used for glass melting in a pot or crucible; a similar furnace is being built for burning refractories. The stirring machine above-mentioned has answered very well. On the platform which is brought over the pot are mounted an electric motor and a system of vertical steel rods, so geared that the stirrer proper can describe a circle of adjustable radius while revolving about its own longitudinal axis, both movements being at variable speeds.

Metallurgical and General Chemistry.—A great volume of very varied work has passed through the laboratories; analyses of aircraft materials for the Aeronautical Inspection Department can now be reported upon within 24 hours of receipt of samples; much work also comes from the Chief Inspector at Woolwich and from the Ministry of Munitions and munition areas. The materials submitted include aluminium alloys and special steels, and often differ widely from the materials formerly sent in. Tests have also to be made of optical glass, and, further, of chemical laboratory glassware and porcelain; these latter have considerably improved in quality since last year. Dopes and varnishes for aircraft fabrics also pass through the laboratories to be tested for durability, weathering in sunlight, permeability to hydrogen and other qualities.

STRESS DETERMINATION IN A FLAT PLATE.*

By MR. J. MONTGOMERIE, B.Sc.

THIS paper sets forth the results of certain tests made upon a rectangular flat plate exposed to normal pressure over its surface. The plate formed one of a series, of varying thickness, experiments upon which were begun in the autumn of 1910 and which have been prosecuted since, as opportunity and leisure permitted. The experiments, which were conducted in the engineering department of the West Ham Technical Institute, where facilities were kindly provided under the direction of Mr. J. Duncan, the head of the department, had for their object the determination of the states of stress existing in flat rectangular mild steel plates of varying thickness when exposed to fluid pressure. In doing so the following objects were aimed at:—

1. The production of conditions of fixity along the edges which should approximate as closely as possible to those upon which the theory of the subject is based.
2. A determination of the stress conditions for values well below the elastic limit, and to this end to secure
3. Methods of measurement of deflection of as delicate a nature as possible, excluding optical methods of types which are not self-contained.
4. The determination of the actual principal axes of strain for various points on the plate and, by actual measurement, to find the strain along these axes.

Although this subject bears very closely upon the work of the naval architect and the civil engineer, yet the available literature upon it is by no means abundant. In this respect the records of this Institution form an honourable exception to a somewhat general rule. Papers have been contributed, amongst others, by the late Mr. Read on the "Strength of Bulkhead Plating,"* in which he investigated in a very ingenious manner the stresses in a strip of thin plating uniformly loaded, on the assumption that the strip could be regarded as a catenary; by the late Dr. Elgar in a paper on the strength of bulkheads,† in which he advanced some general considerations bearing on the subject, and expressed his sense of the necessity for experimental investigations as a supplement to mathematical analyses. Contributions have also been made by Professor Bryan,‡ and by Lieutenant Boobnoff,§ of the Russian Navy, and Dr. Bruhn‖ has made a most valuable contribution to the literature of the subject in a paper before a sister society in which he investigated and combined mathematically the effects of bending and stretching. These, and some others that might be mentioned, have no doubt their value as practical approximations useful for purposes of comparison, but in so far as they proceed on the assumption that the plating may be divided into independent strips they fail entirely to provide any information on

Fig. 1. PLAN OF PLATE SHEWING STATIONS.

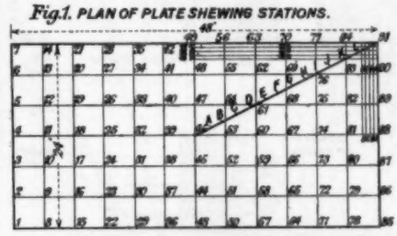
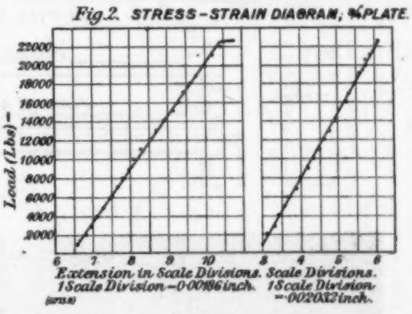
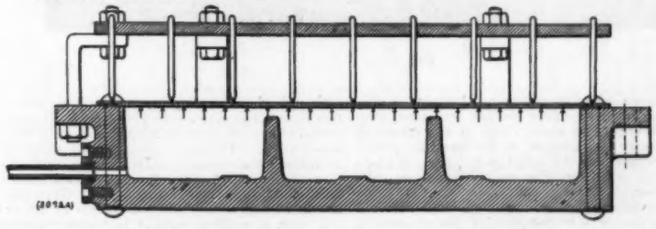


Fig. 2. STRESS-STRAIN DIAGRAM, ¼ PLATE.



BACH'S EXPERIMENTS



* Paper read before the Institution of Naval Architects.

* "Strength of Bulkhead Plating." By T. Read. Trans. I.N.A., vol. xxvii, 1886; ENGINEERING, vol. xli, p. 445.

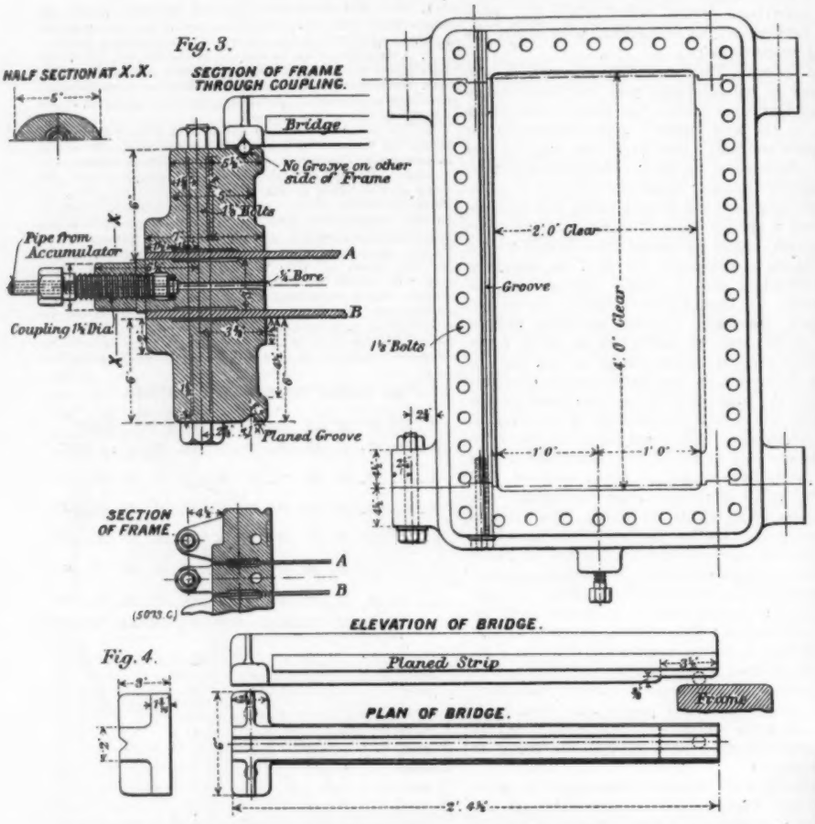
† "Some Considerations Relating to the Strength of Bulkheads." By F. Elgar. Trans. I.N.A., vol. xxxiv, 1893; ENGINEERING, vol. lv, pp. 370, 427.

‡ "On the Theory of Thin Plating and its Applicability to Calculations of the Strength of Bulkhead Plating and Similar Structures." By G. H. Bryan, M.A. Trans. I.N.A., vol. xxxv, 1894.

§ "On the Stresses in a Ship's Bottom Plating due to Water Pressure." By Ivan G. Boobnoff. Trans. I.N.A., vol. xliv, 1902; ENGINEERING vol. lxxiii, pp. 384, 390.

‖ "Methods of Estimating the Strength of Ships." By J. Bruhn, D.Sc. Trans. Institution of Engineers and Shipbuilders in Scotland, vol. xlviii, 1904–5.

STRESS DETERMINATION IN A THIN PLATE.



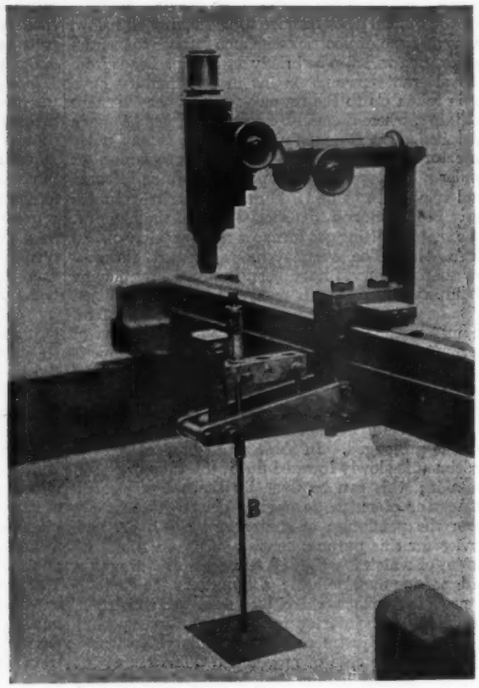


FIG. 5.

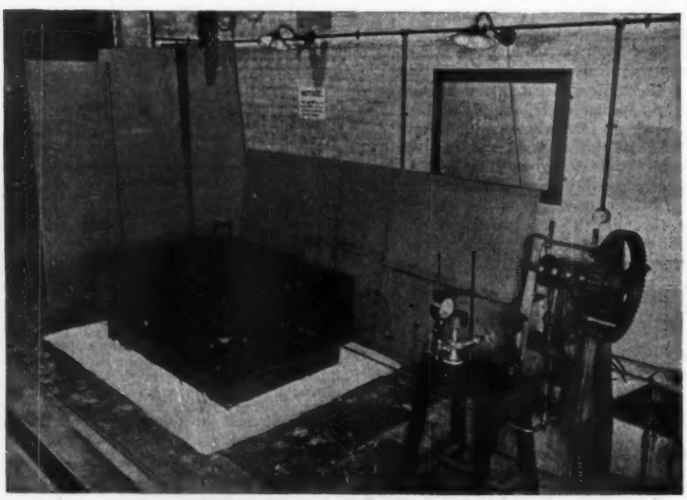


FIG. 6.

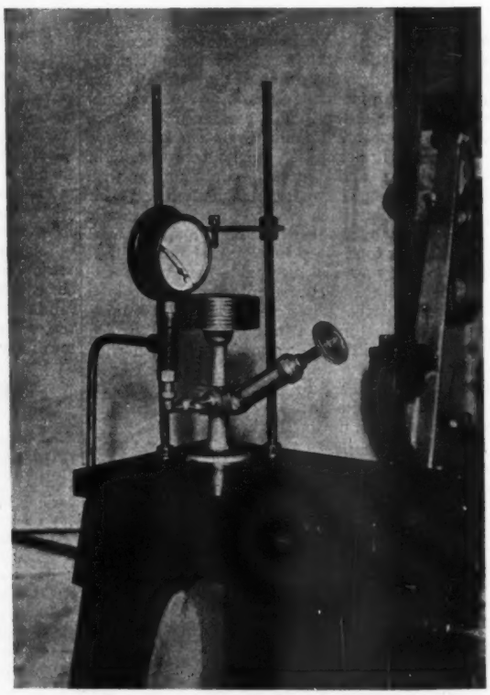


FIG. 7.

the states of stress actually existing. A strip of thin plating in a bulkhead or other similar structure may perhaps be represented at some stage in the straining action by a catenary for example, as Mr. Read supposed, but as the constraint of the adjoining layers of plate has been entirely neglected the results based on such an assumption cannot be accepted.

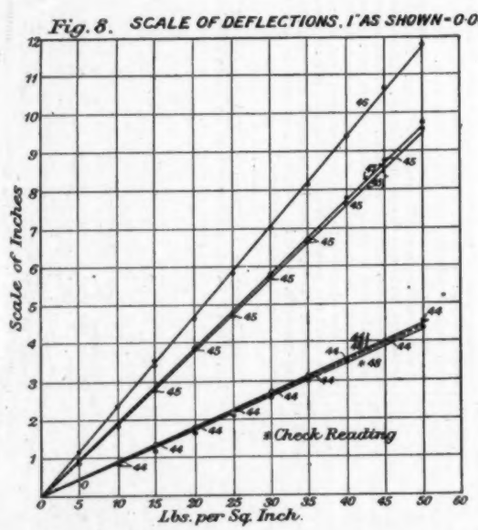
The attention of mathematicians has been directed for many years to the investigation of the stresses in a sheet of plating subject to flexure. Those interested in these investigations may be referred to Todhunter and Pearson's "History of the Elasticity and Strength of Materials," article 474 *et seq.*, and vol. ii, part ii, article 1232 *et seq.* A modern exposition of the mathematics of the subject will be found in Thomson and Tait's "Treatise on Natural Philosophy," part i, article 627 *et seq.* These mathematical investigations, however, do not make any appeal to practical men, although Professor Bryan, in the paper above mentioned, has given a simplified account, very useful to the engineer, of Kirchhoff's mathematical work. The mathematician provides us with the differential equation of the bent surface of the plate*, a solution of which, satisfying the boundary conditions, will determine the deflection at any point in terms of its co-ordinates, but such a solution cannot be found except in the case of a circular or elliptical disc, and we must therefore fall back upon the records of actual experiment.

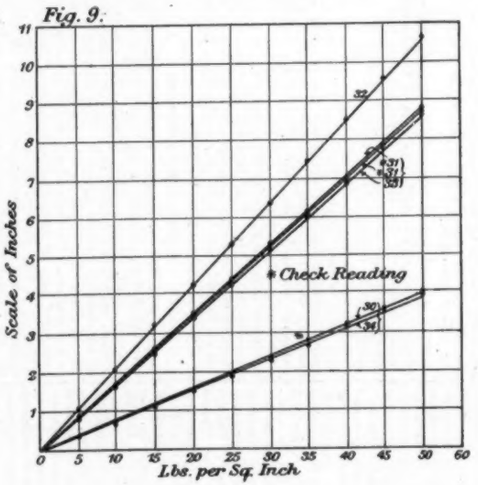
In regard to experimental work an extensive search reveals only two sets of investigations on the subject. One of these is an experimental research on the elastic strength of flat plates by W. J. Crawford,* and consists of a series of experiments on planished steel plates of very small size and thickness, the scale of these being too small to enable any inference to be drawn as regards practical conditions. The experimental work always referred to in this connection is that of

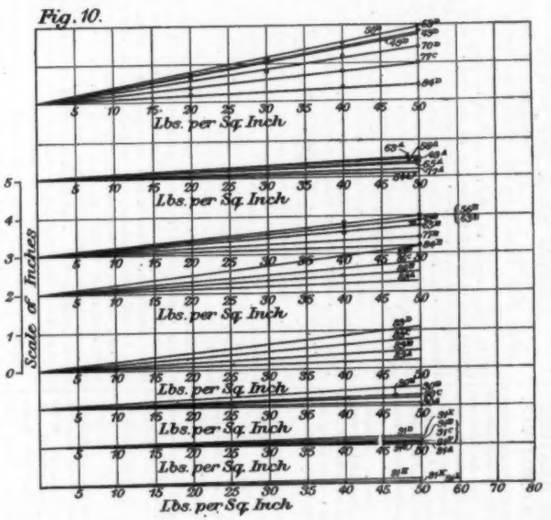
* A $\frac{d^4 z}{d x^4} + 2 \frac{d^4 z}{d x^2} d y^2 + \frac{d^4 z}{d y^4} = Z$. A is a constant; z is load on unit area at point x, y. Thomson and Tait, Part II, page 185.

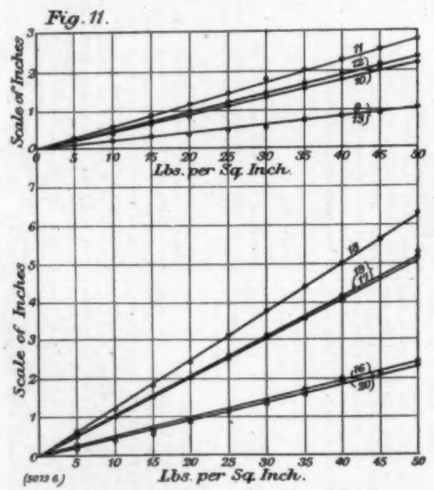
* "The Elastic Strength of Flat Plates." By W. J. Crawford, B.Sc. Proc. Royal Society of Edinburgh, 1911–12.

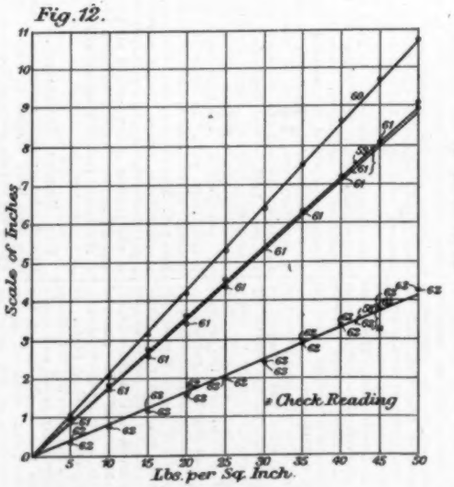
STRESS DETERMINATION IN A THIN PLATE.

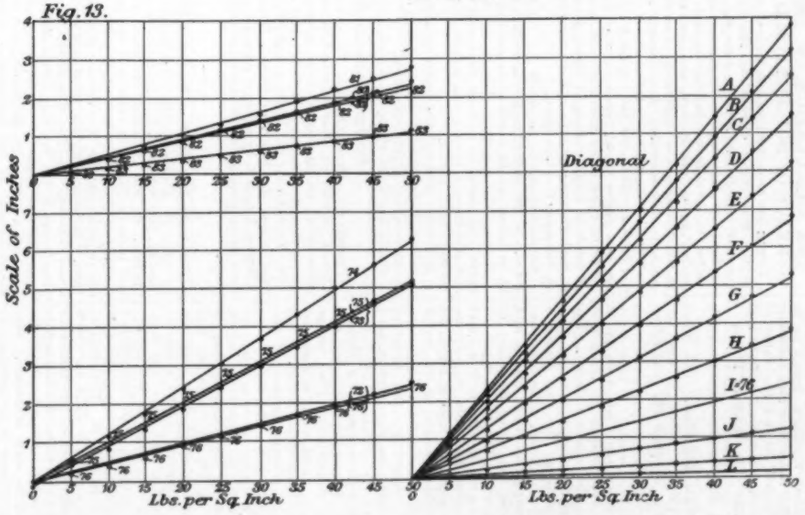












Professor Bach, of the Royal Technical High School, Stuttgart.* He experimented with 4 plates of dimensions 800 mm. by 800 mm. by 8.4 mm., 800 mm. by 800 mm. by 16.8 mm., 800 mm. by 400 mm. by 8.6 mm., and 800 mm. by 400 mm. by 16.5 mm. These plates were riveted to a cast-iron frame in the manner shown on page 35, and deflection measured by a series of spindles at various points on the plates with their ends resting in small cavities in the plate. The plates were of ordinary rolled steel, and the accuracy of the measuring apparatus (the method of which is not clearly shown) is claimed to be 0.01 mm. Exception must be taken to the nature of the end fixing as being of a semi-rigid character only, and the presence of the rivets implies local stresses of an unknown and indeterminate character. His method of determining stress conditions from an analysis of deflections is still more open to criticism. He takes any section of the plate, finds an equation to the curve of deflection as found from experiment, and differentiates twice. From this he finds the strain at any point, and then deduces a value for the stress. But this stress so found need not be the principal stress, since his axes are chosen arbitrarily and do not necessarily coincide with the principal axes of curvature at any point. In addition, no account is taken of the effect of the strain at right angles to that found by him. He makes also a practical application of his results,* and in doing so adopts Bernoulli's conception (although without any reference to Bernoulli) that the load may be considered as supported by a series of strips at right angles to each other, a hypothesis fundamentally unsound.* For these reasons the present writer is not prepared to concede to the experiments of Bach the value that has hitherto been attached to them.

The plate, the results of the testing of which are given in this paper, was a piece cut from an ordinary shell plate with the rolled surface left as it came from the mills. The surface exposed to pressure was 48 in. by 24 in., and this was divided as shown in Fig. 1, page 35. The thickness was micrometrically measured

* "Versuche über die Formänderung und die Widerstandsfähigkeit ebener Wandungen." Berlin, 1908.

* See Todhunter and Pearson's "History of Elasticity," vol. i, article 122; also paper on "Theory of Thin Plating," &c. By G. H. Bryan, M.A. Trans. I.N.A., vol. xxxv, 1894.

* "Zur Widerstandsfähigkeit ebener Wandungen von Dampfkesseln und Dampfgefäßen." Berlin, 1906.

over the whole plate by means of a specially made pair of callipers, and the mean thickness found to be 0.73 in. Strips were cut both lengthwise and crosswise from the plate, and were tested to find the value of Young's modulus (E) by both direct tension tests and bending tests (Fig. 2, page 35). The value of Poisson's ratio, $\frac{1}{m}$, was also found directly by means of the strain-meter to be afterwards described. The mean value of E was found to be (30.5×10^6 in.) lb. and the value of Poisson's ratio (Fig. 3, page 36) was found to be $\frac{1}{3.5}$.

The frame in which the plate was fixed is shown in Figs. 3 and 4, page 36. It consists of three iron castings bolted together in the manner shown. The top and bottom parts are of dimensions 6 in. by 5 in. and the distance piece, separating the two plates A and B, is 7 in. broad by 3 in. in depth. The top plate A is that upon which observations were taken, and the bottom plate B, forming the lower boundary of the water space, is permanent. The total depth of the frame is therefore 16 in., its breadth is 6 in., and these dimensions were adopted not only to provide great fixity along the plate edges, but also to eliminate as far as possible any sensible distortion of the frame when the pressure was applied. That this distortion was inappreciable, having regard to the order of accuracy achieved in the experiments, was demonstrated by a series of observations.

The frame was provided with a travelling bridge, also shown in Fig. 4, to which was attached the instrument for measuring deflections. The bridge traversed the length of the plate and ran in a V-shaped groove pinned to the upper surface of the frame. Ball bearings were provided in the lower surface of the bridge (see Figs. 3 and 4, page 36). The top surface of the bridge had also a V-shaped groove fitted, in which ran the ball bearings of the bracket to which was attached the apparatus for the measurement of deflection. This is shown in Fig. 5, page 36, and consists of a bracket, to the top of which is attached a microscope with a scale engraved in the eyepiece, while to the bottom is pivoted a bent lever, the horizontal arm of which is fitted with holes for the accommodation of a micrometer gauge A with its rounded lower end resting in the cup-shaped socket worked in the upper end of the vertical spindle B. The vertical arm of the bent lever carries a sheet of glass on which a fine line is engraved, and the effect of the deflection of the plate under pressure is to displace this line across the field of the microscope, when the amount of the deflection may be measured in scale divisions. The instrument is calibrated by means of a micrometer, the vertical displacement of the spindle as measured by the micrometer being related to the number of divisions of the eyepiece scale, as observed, and the value of one division of the eyepiece scale being determined. In practice the instrument was focused and then permanently fixed and calibrated. The mean of a series of observations showed that one division of the eyepiece scale (and of course it was possible to read to one-tenth of a division) represented a vertical displacement of the spindle of 0.000875 in.

Fig. 6, page 36, shows the general arrangement of the testing apparatus. The pressure was obtained by means of a three-crank hydraulic pump worked by hand and was measured with great accuracy by means of a Crosby gauge tester (Fig. 7, page 36) with differential adjustment. A shut-off cock allowed the pressure to be retained at any value for an indefinite period.

The work of obtaining deflection measurements from the plate corresponding to given pressures was simple but tedious. Observations were taken over the whole of the plate in order to ascertain the differences caused by local variations in the thickness and in the surface, and in the homogeneous nature of the material throughout the depth, the plate being, as above stated, a portion of an ordinary shipbuilding shell plate. It was found that the differences in the observed deflections due to these causes were exceedingly small and could reasonably be neglected, and this is shown by the plotted results. In the subsequent work of strain measurement and the determination of the principal axes of strain and stress one quadrant only of the plate was considered. After adjustment of the instrument for any given station on the plate the pressure was increased by small increments from zero to 50 lb. per square inch, and the corresponding microscope readings were taken. In some cases the readings were also taken for progressively diminishing pressures, and in all cases the return zero reading was checked with that at the starting-point. These results were plotted in terms of pressure for each station, and they are shown in Figs. 8–13, page 37, and an examination of these shows that in every case the relation between pressure and deflection is constant that is, the effect of stretching or vaulting of the plate is inconsiderable for this thickness and span.

(To be continued.)

STEAM CARGO WINCHES OF THE "AURANIA."—In such a vessel as the Cunard liner Aurania, which we illustrated in the previous volume of ENGINEERING, page 609, the winches and windlass equipment is always of interest. These were supplied by Messrs. John H. Wilson and Co., Limited, of Liverpool, and it may be said that of horizontal double-geared winches there were six with cylinders of 8 in. by 12 in., three with cylinders of 7 in. by 10 in., and two with cylinders 12 in. by 16 in., in addition to four single boat winches, with extended ends, with cylinders 6 in. by 8 in. The steam windlasses were designed for 2 $\frac{1}{16}$in. cables.

THE CALCULATION OF THE HEATING SURFACE OF BOILERS FOR LOCOMOTIVES.

THERE has been from time to time some slight difference in the method of calculating the heating surface of locomotive boilers. A little time ago the Association of Railway Locomotive Engineers appointed a committee to investigate the matter, and decided that the method to be employed by the members—to be known as the "Association of Railway Locomotive Engineers' method of calculating the heating surfaces of locomotives"—should be as follows :—

Fire-box.—The outside (wetted surface, of inner fire-box plates to be taken to top of foundation ring. Areas of tube holes and sectional area to wetted side of fire-hole ring, or flanged plate, as the case may be, to be deducted ; section of fire-hole being taken close up to the inner fire-box plate.

No deductions to be made for copper stays or roof stays. If the boiler has fire-box water tubes the surface to be taken on the inside (wet side) of tube.

Tubes.—The outside surface of tubes (wet side) to be taken, calculated on uniform diameters for both ordinary and superheater tubes ; the length of tube being taken between tube plates.

Elements.—The inside surface (steam side) of elements to be taken, the effective length of tube being from and to smoke-box end of large flue tube.

Smoke-box Tube Plate.—No allowance to be made.

PERSONAL.—Messrs. Ruston, Proctor and Co., Limited, Lincoln, inform us that they have moved their London office from 46, Queen Victoria-street, E.C., to West Africa House, Kingsway, W.C. 2.—Mr. James A. Goodwyn, Mr. John H. W. Pawlyn and Mr. Victor W. Bone have joined the board of Messrs. Ransomes, Sims and Jefferies, Limited, Ipswich, as managing directors. They have been responsible members of the staff for many years.

THE LATE MR. THOMAS WHARTON FORD.—We regret to have to announce the death, which occurred on Sunday, the 8th inst., at his residence 19, Edith-grove, Chelsea, of Mr. Thomas Wharton Ford. Mr. Ford was born on May 28, 1868, and received his scientific training at University College, London. He then served his pupilage under Mr. James Holden from 1885 to 1889. Subsequently Mr. Ford entered the offices of the Great Eastern Railway Company, Stratford, and was three years in the drawing office, acting, later, for two years in the capacity of departmental manager and two and a half years as inspector of material both at Stratford and at the contractors' works. During his three years in the drawing office he was for a few months connected with the competitive trials between compound and simple expansion locomotives. In 1897 he commenced working on his own account in Victoria-street, and represented the interests of some large Sheffield manufacturing concerns. In 1899 Mr. Ford entered into partnership with Mr. John P. O'Donnell, Palace-chambers, Westminster, when he visited the United States and secured the patents relating to compressed air and pneumatic machinery, in connection with which a company was formed of which he was appointed managing director and technical adviser generally. In the year 1904 he was appointed director of the British Pneumatic Railway Signal Company, Limited, whose application of low-pressure system of pneumatic signalling we described in a former issue (ENGINEERING, vol. lxxxii, page 417). In 1908 Mr. Ford was appointed manager of the London office of Messrs. Craven Brothers, Limited, Manchester and Reddish, manufacturers of machine tools, cranes, &c., a position which he retained until his death, together with that of consulting engineer in the matter of compressed air machinery. Mr. Ford was a member of the Institution of Civil Engineers and of the Institution of Mechanical Engineers.

THE BRITISH ASSOCIATION.—The Council of the British Association announced some time ago that they had been obliged to cancel this year's meeting, which was to take place at Bournemouth, after consulting the prospective hosts, the Bournemouth authorities, and His Majesty's Government. This is the first time since 1831 that the British Association has not been able to assemble, and we sincerely hope Sir Arthur Evans, president of the Newcastle meeting of 1916, would have vacated the chair at Bournemouth in favour of the president-elect, the Hon. Sir Charles Parsons. It has been resolved that Sir Arthur Evans will remain president for this year, and that Sir Charles Parsons will preside over the meeting to be held at Cardiff in 1918 ; the date is not yet fixed. In reluctantly withdrawing the invitation for 1917 Bournemouth had expressed the wish soon to entertain the Association ; the invitation has since been renewed and accepted for 1919. When members were informed of the abandonment of this year's meeting they were reminded that the Association depends mainly upon the members' subscriptions for maintaining the machinery of the Association and for supporting by grants the researches carried out by various committees. These grants had much to be cut down, of course, this year ; in this respect it is almost fortunate that a number of committees have not been in a position to continue research during war time, and that others have been absorbed into national committees. Section G, Engineering, did not claim any grant ; Section A, Mathematical and Physical Science, received 100*l.* for seismological investigations ; and Section B, Chemistry, 17*l.* for the committees on capillary chemistry and non-aromatic compounds. Several of the other sections did not apply for grants.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—In the steelmaking industry the prevailing note is still that of ceaseless activity, every effort being made to effect a certain clearance of work before the holidays commence at the end of this week. To attain this end and keep things going on as satisfactory a basis as possible, manufacturers have striven to increase the already abnormal output and so decrease the arrears which have steadily accumulated. One remarkable feature of steel production recently is the manner in which, in numerous instances, the demand for certain classes of material has advanced while that for others has diminished, so that the top level rate is well maintained. Thus the production of plates, sections, angles and other shipbuilding material now occupies a very prominent position, every variety being in exceptionally heavy demand. Steel for shell bars is also in urgent request, and in every direction Government orders have complete preference. During the holidays opportunity will be taken to overhaul plant and machinery, upon which so severe a strain has been put within the past few months, and to execute all necessary repairs.

Malleable Iron Trade.—In the malleable iron trade makers continue to be faced with the difficult problem of satisfactorily meeting all the demands put upon their resources. Production remains on a high level, but Government alone can easily absorb the entire output, the naval and military requirements becoming more and more urgent as time goes on. There is thus little or no material available for the use of ordinary home consumers. The prohibition of the export of steel and the Government demand for iron have practically shut the door on overseas trade in the meantime.

Scotch Pig-Iron Trade.—The demand for Scotch pig-iron of all grades shows no diminution, hematite still leading the way, every ton produced being quickly swallowed up by the local steel works, while the iron works as speedily absorb the entire available output of foundry quality. The end of the week will see a general damping down of the blast-furnaces on account of the Fair Holidays, so that a bold effort is being made to overtake delivery of all arrears by Thursday at latest. No change has taken place in home prices, and those for export keep firm.

Glasgow and Inland Waterways.—A very interesting event in connection with the Inland Waterways and Docks Section of the Royal Engineers has just taken place in Glasgow through the patriotic generosity of a noted West of Scotland firm, Messrs. P. and W. Anderson, builders and contractors, Douglas-street, Glasgow, who have offered to the Government the use of their entire organisation and plant for the purpose of the carrying out of important constructional work for this valuable branch of the Army. Needless to say the offer was gladly accepted, and recruiting for the corps is rapidly being pushed forward at Bristol. It is perhaps unnecessary to say that the transference of such a magnificently equipped business to the service of the nation is probably unique in Army annals, and will no doubt be valuable beyond measure.

NATIONAL WELFARE AND ECONOMY EXHIBITION.—This exhibition, which is being held in the new County Council Hall, Westminster Bridge, S.E., and is to remain open until August 11, contains a large number of exhibits of general interest. The display made by the Ministry of Munitions will appeal more especially to our readers. This contains a collection of projectiles, guns, &c., lent by various departments of the Ministry ; a display of wire screens and machinery guards, patent seats, lockers, washing troughs and other works furniture by the Crittall Manufacturing Company, and a "shell and fuse factory," with assembling room, illustrating the manufacture of shells and fuses.

TUBING FOR ELECTRIC WIRES.—In a recent issue of the *Electrical World* Mr. R. Radcliffe describes the following plan of making tubing for the protection of electric wires :—"Coat a straight brass or iron rod heavily with melted paraffin and allow it to cool. Then mix one part of plaster of Paris with two and one-half parts of water, adding a small quantity of lime. Tear muslin strips 1 in. wide and dip in the mixture. After allowing them to absorb all they will hold, wind them smoothly around the rod, working slantwise, end to end. Enough layers may be applied to give the desired thickness. When the plaster is thoroughly hardened beat the metal core until the paraffin is soft enough to permit removal of the rod. Tubing made in this way is a non-conductor, heat-resisting, slightly flexible, and can be cut into desired lengths with a hacksaw."

THE INSTITUTE OF METALS.—The Council of the Institute of Metals announce that an extra election of members will take place on July 18. Those desirous of applying for membership of the Institute are invited to write to the secretary of the Institute, 36, Victoria-street, Westminster, S.W. 1, for a copy of the new membership booklet, comprising 88 pages, which includes an up-to-date list of the Institute's 760 members. The membership of the Institute has recently shown a very considerable increase, more additions to the roll having been made during the past six months than in the previous three years. A new financial year of the Institute commences this month. The annual autumn meeting of the Institute of Metals will be held on Wednesday, September 19, in the rooms of the Chemical Society, Burlington House, London, W. 1. Many interesting papers will be submitted for discussion.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Hull Coal Traffic.—Details of the coal traffic at the Humber port are not very informative, and once again no returns are available of the tonnage sent abroad. There are few cases where collieries have sent a larger tonnage than last year, though the fluctuations are of a considerable character and represent the demands made upon the individual firms from the authorities. The chief contributing firm, Denaby and Cadeby Main, with a total of 24,863 tons, has sent nearly 20,000 tons less than in June a year ago; whilst Grimethorpe and Frickley pits, usually a strong second on the list, have sent only 6,974 tons. Two firms, Bullcroft and Acton Hall (a West Yorkshire pit), have, in addition to Denaby and Cadeby Main, sent over 10,000 tons, the former showing an increase of about 5,000 tons. On the other hand, Askern Main has an increased tonnage of 4,500 tons, while Brodsworth, Bentley and Bullcroft Collieries have sent approaching 3,000 tons less each.

South Yorkshire Coal Trade.—The principal demand is for the larger sorts of manufacturing fuel, though there is no falling-off in any of the other branches. Still, collieries seem to be more concerned to give full supplies of the class named, for the inland consumption alone is very heavy. Cobbles, too, are in big request, and for steam nuts there is an active inquiry. The gas coal market has the same tight tone which has characterised it for the past few weeks, and companies are unable to obtain the full amount on their contract orders. The open market business is practically at a standstill, for supplies are barely sufficient to cover contracts. Export business is also much below what was formerly the case, though the tonnage for Allied Powers and Government is by no means a small figure. The house coal market is busy with orders for stocking purposes, but there is some danger of arrears being more than dealers and depots can cope with in view of the stringency of supplies. Quotations:—Best branch hand-picked, 20*s.* 6*d.* to 21*s.* 6*d.*; Barnsley best Silkstone, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire best brights, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire house coal, 17*s.* to 18*s.*; best large nuts, 16*s.* 6*d.* to 17*s.* 6*d.*; small nuts, 15*s.* 6*d.* to 16*s.* 6*d.*; Yorkshire hards, 16*s.* 6*d.* to 17*s.* 6*d.*; Derbyshire hards, 16*s.* to 17*s.*; best slacks, 12*s.* to 13*s.*; seconds, 10*s.* 6*d.* to 11*s.* 6*d.*; smalls, 7*s.* 6*d.* to 8*s.* 6*d.* per ton at the pit.

Iron and Steel.—The pronounced activity continues unabated, and the general demand for steel is producing a condition of stringency in the market. This leads to further difficulties for those who are anxious to get steel for other than direct war work. The output of wire and wire rods is being restricted by the shortage of material, but there are confident hopes that this will be made good in the course of the next few days. Almost the whole of the production of the Sheffield furnaces is now stated to be of the acid brand, and basic qualities are being obtained from outside. This change is regarded as part of the scheme of the Ministry of Munitions for concentrating at one particular spot the production of what the given district is most capable of. The result has been, in Sheffield, to permit of a larger output of the very necessary acid billets than would have been the case without co-ordination. The basic deliveries are also on a good scale, which points to a similar successful achievement elsewhere. Progress is recorded in the output of pig-iron. Derbyshire makers find Sheffield firms their chief consumers, and there is a demand for all they can put on the market. More furnaces are being converted to the production of the basic quality, but there is now a more regular amount of both forge and foundry iron finding its way to the works. With the inquiry so brisk it is not in the least surprising to find that the prices remain at the maximum all round. Heavy foundries are busy with castings of a rather important character. Shell shops are not so hard pressed as formerly, for there is a much easier tone in this section. The contrary is the case with aeroplane work, which is being speeded-up in a manner reminiscent of the days when there were cries of "shell shortage." Railway steel orders are gradually growing in size, and more tramway work is coming to hand. Contracts have been placed here by municipal undertakings for the early delivery of manganese points and crossings. The general level of the foreign and Colonial trade is good. Indeed, the demand on the part of the Colonies for steel of all descriptions is one of the heaviest yet recorded. Other branches would be in proportion if it were not for the question of labour and material here at home.

COAL TRANSPORT REORGANISATION SCHEME.—The Controller of Coal Mines has announced that a scheme is to come in operation on September 10 whereby it is estimated to save no less than 700,000,000 ton-miles annually in the transport of coal by railways. Maps have been prepared showing that Great Britain has been divided into 20 areas; the scheme relates solely to that portion of the coal which is being transported from area to area for inland consumption. In the various areas District Coal and Coke Supplies Committees are sitting as the Controller's representatives in all matters relating to coal, and these Committees have been empowered by the Controller to conduct the necessary arrangements for putting the new scheme into force. Collieries in each area will thus be placed in direct touch with the factors, merchants and direct consumers, whose supplies they will have to provide in future. The scheme does not affect water-borne coal, either export, coastwise or bunkers, anthracite or coke of any description. The offices of the Controller of Coal Mines are at 8, Richmond-terrace, Whitehall, S.W. 1.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Though home trade in Cleveland pig-iron is quieter, owing to consumers here being well bought under the July allocations, and demand on behalf of customers north of the Tweed being small in consequence of the Scottish holidays, the market presents no sign of weakness. Notwithstanding prolonged strain, furnaces are working admirably, with the result that good proportions of the better qualities of pig-iron are being produced. Export prospects may be said to be satisfactory, as iron is plentiful and the tonnage situation is improving, so that heavier shipments to our Allies are looked for. American export prohibitions threaten to terminate the intermittent trade between America and Scandinavia which merchants here have been transacting under Foreign Office licences. For home consumption No. 3 Cleveland pig, No. 4 foundry, and No. 4 forge are all quoted 92*s.* 6*d.*, and No. 1 is 96*s.* 6*d.*; whilst for shipment to France and to Italy No. 3 is 102*s.* 6*d.*, No. 4 foundry 101*s.* 6*d.*, No. 4 forge 100*s.* 6*d.*, and No. 1 107*s.* 6*d.*

Hematite Iron.—There is intense demand for hematite iron both on home and foreign account. Under strict official supervision deliveries to customers reachable by rail continue on an adequate scale, and further negotiations for sales to home buyers are proceeding. Shipments against running contracts are fairly satisfactory, but there are still obstacles difficult to overcome in the way of new export business, not the least among them being the question as to price and delay in allotments. Export quotations are more or less nominal. Nos. 1, 2 and 3 are 122*s.* 6*d.* for home use, and are put at 137*s.* 6*d.* for shipment to France and 142*s.* 6*d.* for export to Italy.

Foreign Ore.—A fair amount of business in foreign ore has been put through lately, and imports show some improvement.

Coke.—Local demand for coke continues heavy, and descriptions needed for the local blast-furnaces still command fixed maximum rates, average kinds selling at 28*s.* at the ovens, and low phosphorus sorts remaining at 30*s.* 6*d.* at the ovens.

Manufactured Iron and Steel.—There is no abatement in the demand for finished iron and steel, and to meet the Government requirements and the needs of the shipyards manufacturers are working at very high pressure. Little material is left over for sale in the ordinary way of business. Prices are very stiff. To home customers common iron bars are 13*l.* 15*s.*; best bars, 14*l.* 2*s.* 6*d.*; best best bars, 14*l.* 10*s.*; iron ship plates, 15*l.* 10*s.*; iron ship angles, 13*l.* 15*s.*; iron ship rivets, 18*l.*; packing iron and steel (parallel), 13*l.*; packing iron and steel (tapered), 15*l.* 5*s.*; steel bars (no test), 14*l.* 10*s.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel ship rivets, 20*l.* and upward; steel boiler plates, 12*l.* 10*s.*; steel joists, 11*l.* 2*s.* 6*d.*; steel strip, 17*l.*; steel hoops, 17*l.* 10*s.*; and heavy sections of steel rails, 10*l.* 17*s.* 6*d.*

Blastfurnacemen's Wages Advanced.—The average net selling price of No. 3 Cleveland pig-iron for the quarter ended June 30 last having been certified at 94*s.* 4.91*d.* per ton, as compared with 89*s.* 8.76*d.* per ton for the previous three months, under sliding scale arrangements North-East Coast blastfurnacemen's wages are advanced by 6 per cent., raising them from 72 per cent. above the standard to 78 per cent. above the standard.

Consett Steelmakers' Wages.—The secretaries to the Board of Conciliation and Arbitration for the Manufactured Iron and Steel Trade of the North of England, in a return based upon the accountant's ascertainment of the average net selling price of steel plates at Consett during the months of March, April and May, report that under sliding scale arrangements wages of steel millmen remain the same this quarter as during the preceding three months, viz., at the rate of 62½ per cent. above the standard. Since the commencement of the war Consett steelworkers have received advances equivalent to 47½ per cent.

Cleveland Miners' Wages.—A conference of Cleveland ironstone mine owners and miners' representatives have agreed that the present district percentage of 95.25 be converted into 105 per cent., inclusive of war bonus. The advance takes effect from the 23rd inst.

PETROL SUPPLIES FOR COMMERCIAL MOTOR VEHICLES.—The Commercial Motor Users' Association has for some time past been in communication with the Petrol Control Committee, and more recently with the Petrol Control Department of the Board of Trade, with a view to assistance being rendered to those of its members who have been most seriously affected by the further curtailment in petrol supplies. A special committee of the association, which was appointed to draw up a memorandum on the subject for submission to the Petrol Control Committee, was eventually received as a deputation, and was successful in arranging that, in cases where the association, after thorough investigation, is satisfied that a member engaged on war work or on work of national importance is suffering genuine hardship through insufficient supplies of petrol, such cases will, on the recommendation of the association, receive further consideration by the Petrol Control Department. Certain detailed information must be forwarded, in the first instance, to the association. Particulars may be obtained from Mr. F. G. Bristow, F.C.I.S., the secretary, 83, Pall Mall, S.W. 1.

NOTES FROM THE SOUTH-WEST.

Cardiff.—Interest continues to be centred almost exclusively on the conditions which now govern the buying and selling of coal on the market under the Coal Controller's new fixed prices scheme. The Classification Committee completed its work this week, and it is understood that it will be sent immediately to the Coal Controller for his approval. The difficulties over which the market is concerned, however, are those which must almost inevitably arise out of the scheduling. For example, in the South Wales area no fewer than 40 collieries are producers of cargo smalls, for which a uniform price of 20*s.* is fixed. With business so depressed as it is now, orders will almost necessarily go to the few collieries at the top of the list, so that while the few may have a modest feast of business, others—and perhaps the majority—will have to suffer from something approaching a famine. Similar questions will arise over the practical working of the list in regard to large coals, while in regard to the supply of bunkers, shipowners will have peculiar grievances of their own. On Wednesday a letter was posted up on 'change, which had been received from Mr. E. J. Elliott, of the Central Coal Exports Committee, explaining that where the exporter has any difficulty in stating precisely the grade of coal that he may be able to ship he may state that the coal is to be shipped from a certain range of the classes specified in the schedule of prices "at the price prescribed in the schedule," but that in this connection it should be noted that the latitude to be taken must be reasonable, and also that a pretty close indication as to the collieries or groups of collieries from which the coal will be drawn should be given. This explanation will at any rate ease matters for the time being, but the feeling on the market is anything but optimistic as to the prospects. Pitwood is easy at from 65*s.* to 70*s.* and patent fuel quotations are ruling up to 32*s.* 6*d.*

Newport.—The position of the market in regard to Newport coals is unchanged. The Monmouthshire collieries at the moment, however, are fairly well supplied with tonnage, and employment in the Western and Eastern Valleys is good, but the arrivals during the middle part of the week were not so numerous as they were over the week-end, with the result that the supply of empty wagons is again falling off. The amount of new business passing is infinitesimal and is restricted by the uncertainties prevailing as to the practicability of the fixed prices scheme.

Inland Coal Supplies.—Interest on the Cardiff Exchange in the Coal Controller's scheme for the distribution of inland supplies has been limited by reason of the fact that the production of coal for inland consumption is one of the less important features of the coal trade of South Wales. Approximately between 35,000,000 tons and 40,000,000 tons of the total of the Welsh collieries is either exported as cargo to foreign destinations, consumed as bunkers, or shipped coastwise, and all these coals, as well as anthracite, are excluded from the scope of the new distribution scheme.

Welsh Railway Fusion.—The appointment of Mr. E. F. Prosser to the general managership of the undertakings of the Taff Vale, Rhymney and Cardiff Railway companies has been generally interpreted as a step in the direction of a closer understanding between the three concerns which convey from the pits to the docks nearly the whole of the coal exported from Cardiff. The appointment possesses a significance the importance of which will only be realised in the future, when the considerations which have determined the appointment have been crystallised into a definite working agreement, and when that agreement has been put into operation. The three companies have not yet settled the details of the scheme of fusion or co-operation in the control, but the main principles have been agreed upon.

GASHOLDER AT THE TOTTENHAM LIGHT, HEAT AND POWER WORKS—ERRATUM.—In our last week's issue, at page 7, we stated that the tank for the gasholder was constructed by Messrs. Cyrus Robinson and Co., of Queen Anne's Chambers, Westminster. The name should have been Messrs. R. Robinson and Co., of that address. We regret the error.

REDUCTION IN AGE LIMIT FOR DRIVING LICENCES.—In view of the constantly increasing shortage of drivers of commercial motor vehicles, the Commercial Motor Users' Association has had under consideration, since the end of 1915, the desirability of the temporary lowering of the minimum age for the holding of motor car driving licences, subject to satisfactory safeguards in the public interest. The association again recently brought the matter to the notice of the Government authorities, and has now, on the request of the Local Government Board, submitted a memorandum on the subject. The association suggests, *inter alia*, that such licences shall only be issued on the following conditions, and that such modification of the Motor Car Act shall be effected as a temporary war measure, under the Defence of the Realm Regulations, or by other Order, and not by any general alteration of the Motor Car Acts:—(*a*) That the licence shall only be issued to a male person between 16 and 17 years of age, on the written certificate of an intending employer that the applicant is a fit person to be licensed. (*b*) That the licence shall bear the name of such employer, and shall not be valid in any other employment or in respect of the driving of public-service vehicles. (*c*) That the licence shall be a provisional one, available for an initial period, and shall be subject to confirmation at the end of that period only if the employer furnishes a written confirmation of the original application.

THE CORROSION OF CONDENSER TUBES.

(For Description, see Page 44.)

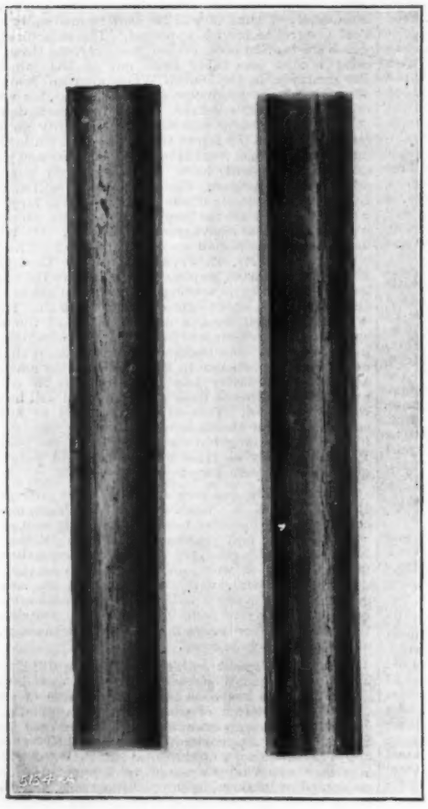


FIG. 1.

FIG. 2.

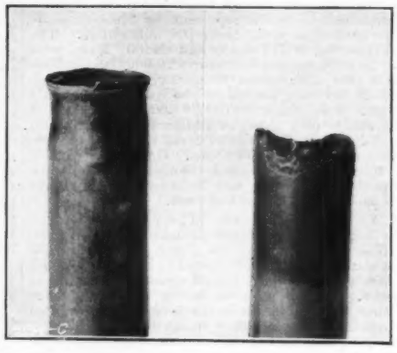


FIG. 5.

Fig.6.

FIG. 3.

FIG. 4.

FIG. 7.

THE HARLEM RIVER SUBWAY TUNNEL, NEW YORK.

THE ARTHUR McMULLEN AND HOFF COMPANY, CONTRACTORS, NEW YORK.

(For Description, see Page 32.)

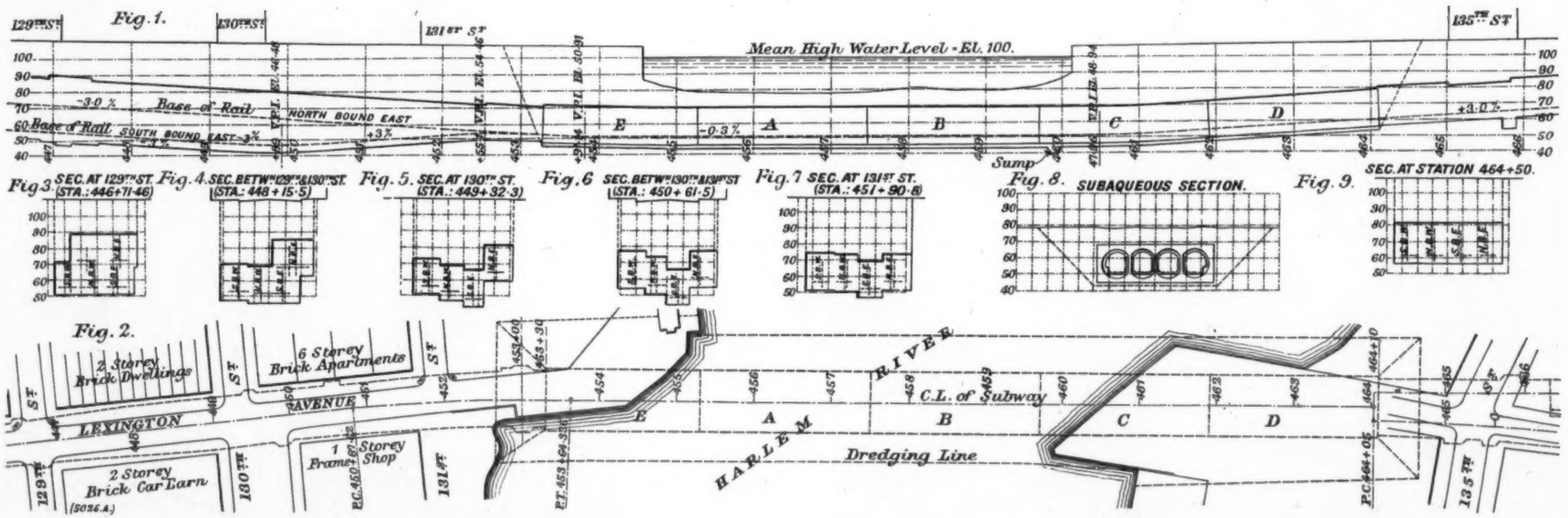


Fig. 1.
Mean High Water Level - El. 100.
Base of Rail
NORTH BOUND EAST
SOUTH BOUND EAST
Sump
Fig. 2.
2 Storey Brick Dwellings
6 Storey Brick Apartments
LEXINGTON AVENUE
2 Storey Brick Car Barn
1 Storey Frame Shop
RIVER
HARLEM
C.L. of Subway
Dredging Line
Fig. 3. SEC. AT 129TH ST. (STA.: 446+71·46)
Fig. 4. SEC. BETW. 129TH & 130TH ST. (STA.: 448+15·5)
Fig. 5. SEC. AT 130TH ST. (STA.: 449+32·3)
Fig. 6 SEC. BETW. 130TH & 131ST ST (STA.: 450+61·5)
Fig. 7 SEC. AT 131ST ST. (STA.: 451+90·8)
Fig. 8. SUBAQUEOUS SECTION.
Fig. 9. SEC. AT STATION 464+50.

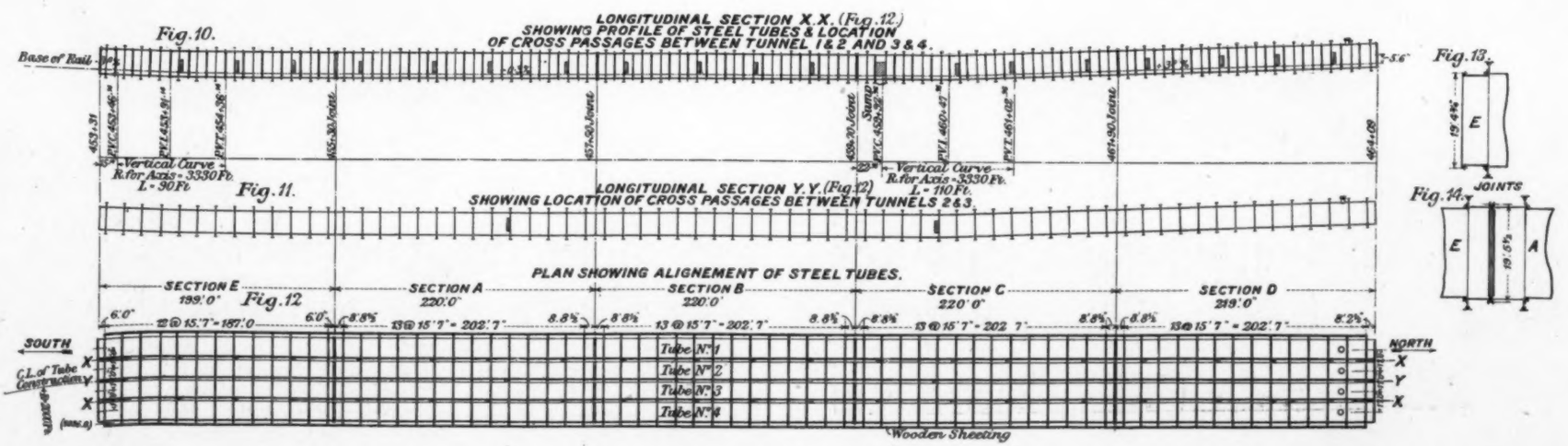


Fig. 10.
LONGITUDINAL SECTION X.X. (Fig. 12.)
SHOWING PROFILE OF STEEL TUBES & LOCATION OF CROSS PASSAGES BETWEEN TUNNEL 1 & 2 AND 3 & 4.
Base of Rail
Vertical Curve R. for Axis = 3330 Ft. L = 90 Ft
Vertical Curve R. for Axis = 3330 Ft. L = 110 Ft.
Fig. 11.
LONGITUDINAL SECTION Y.Y. (Fig. 12)
SHOWING LOCATION OF CROSS PASSAGES BETWEEN TUNNELS 2 & 3.
PLAN SHOWING ALIGNEMENT OF STEEL TUBES.
Fig. 12
SECTION E 199'0"
SECTION A 220'0"
SECTION B 220'0"
SECTION C 220'0"
SECTION D 219'0"
SOUTH
NORTH
C.L. of Tube Construction
Tube N°1
Tube N°2
Tube N°3
Tube N°4
Wooden Sheeting
Fig. 13.
Fig. 14.
JOINTS

(To face page 32.)

THE HARLEM RIVER SUBWAY TUNNEL, NEW YORK.

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(*For Description, see Page* 32.)

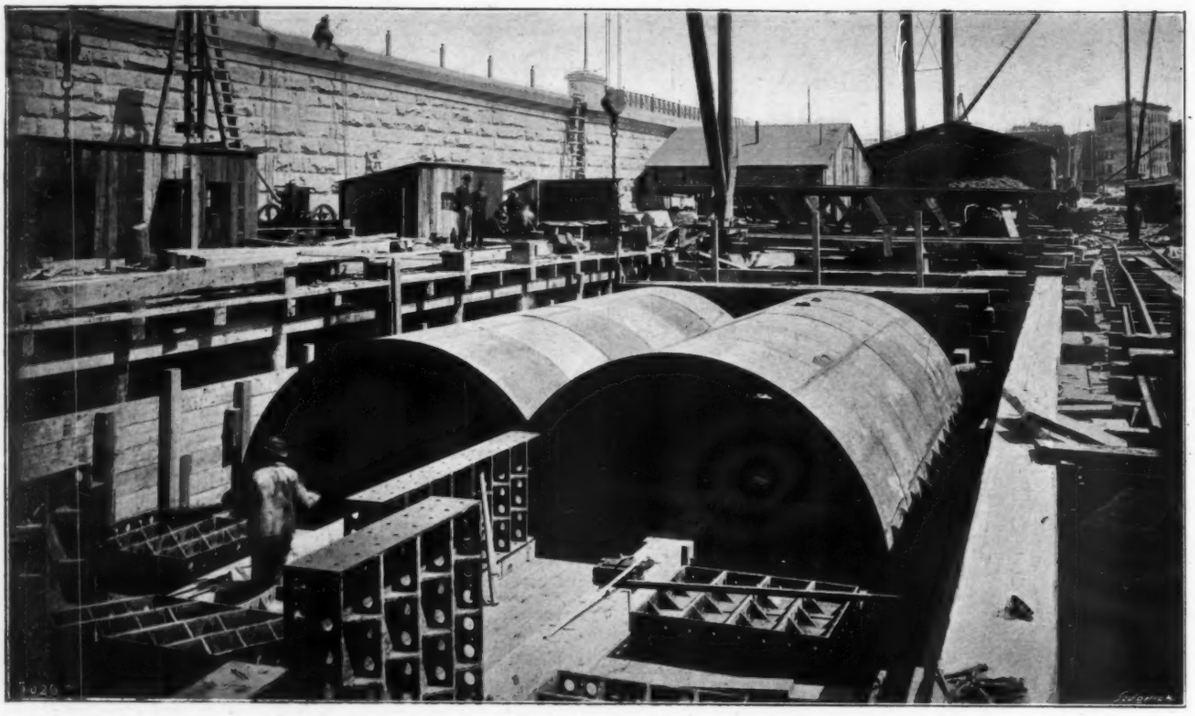

FIG. 15. TUBES IN COURSE OF CONSTRUCTION AT CONTRACTORS' YARD.

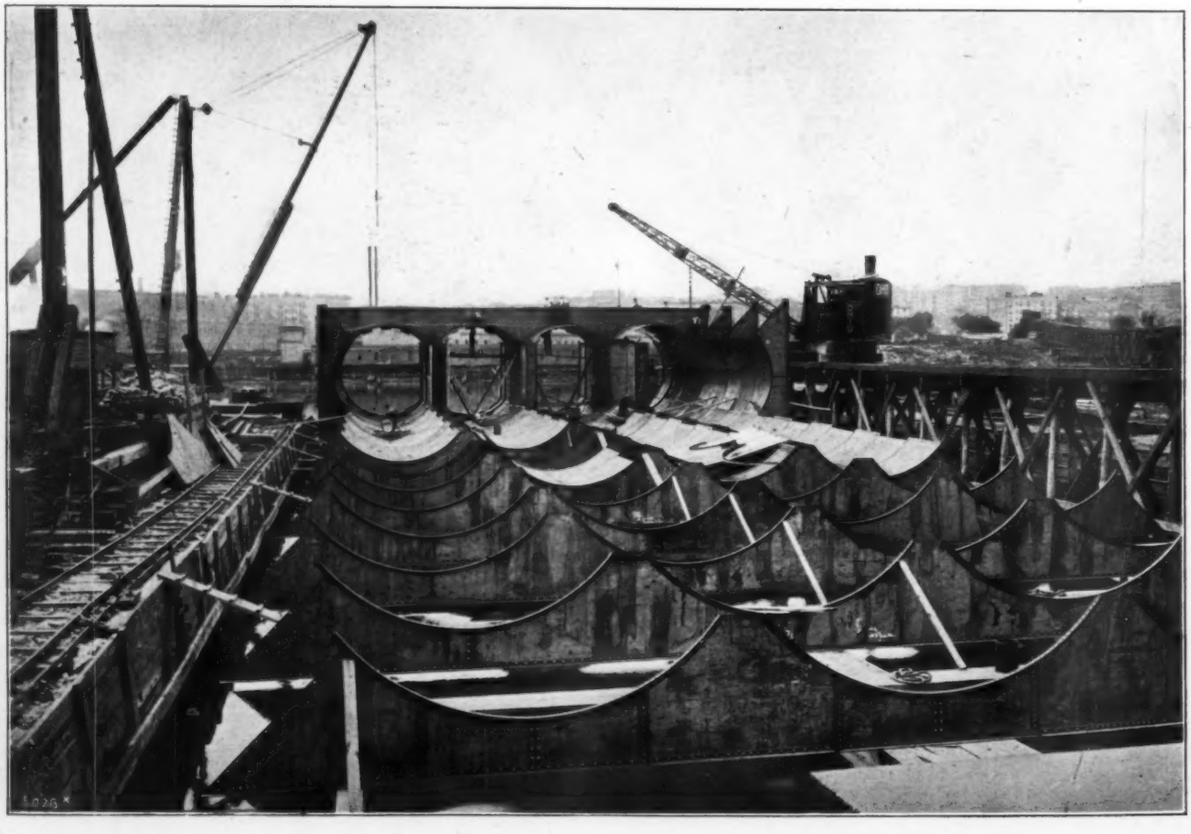

FIG. 16. TUBES IN COURSE OF CONSTRUCTION AT CONTRACTORS' YARD.

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(*For Description, see Page* 32.)

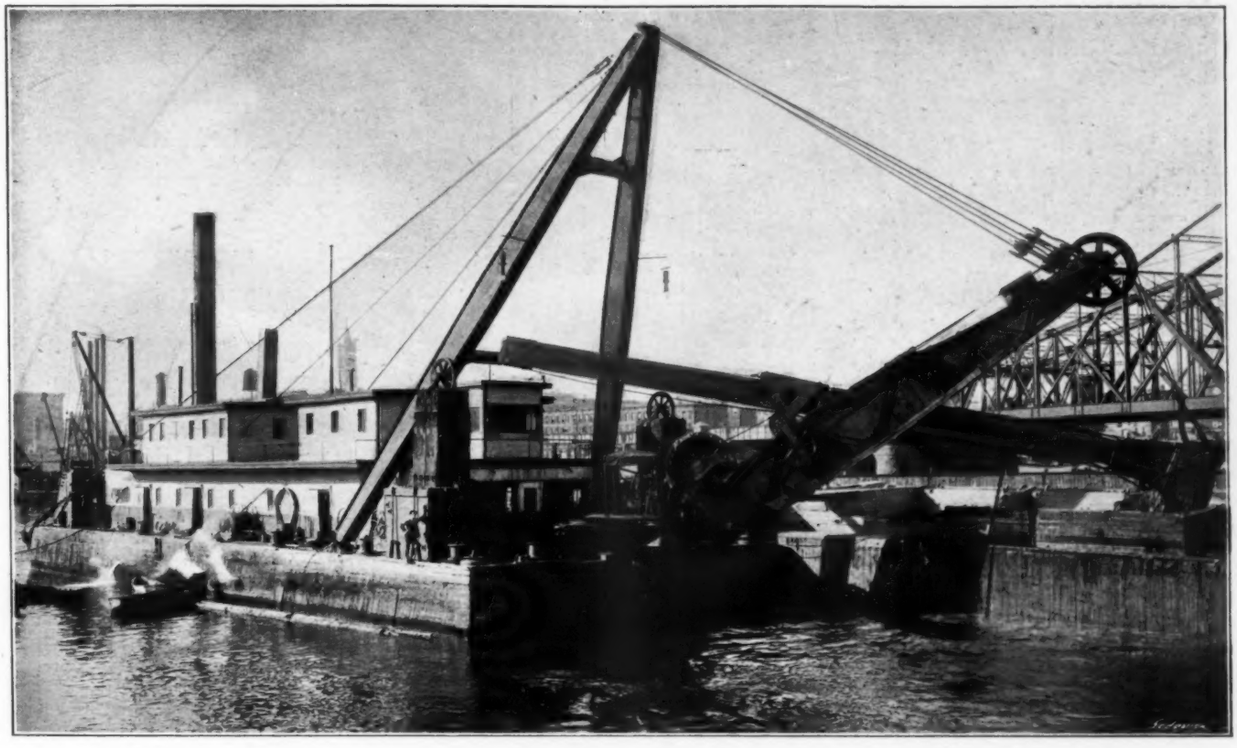


FIG. 18. DIPPER DREDGE WITH 7-YARD BUCKET.

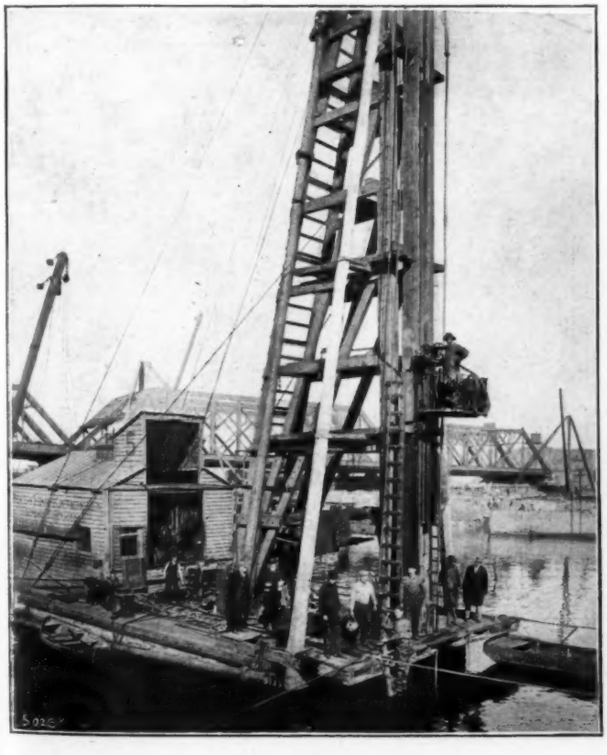


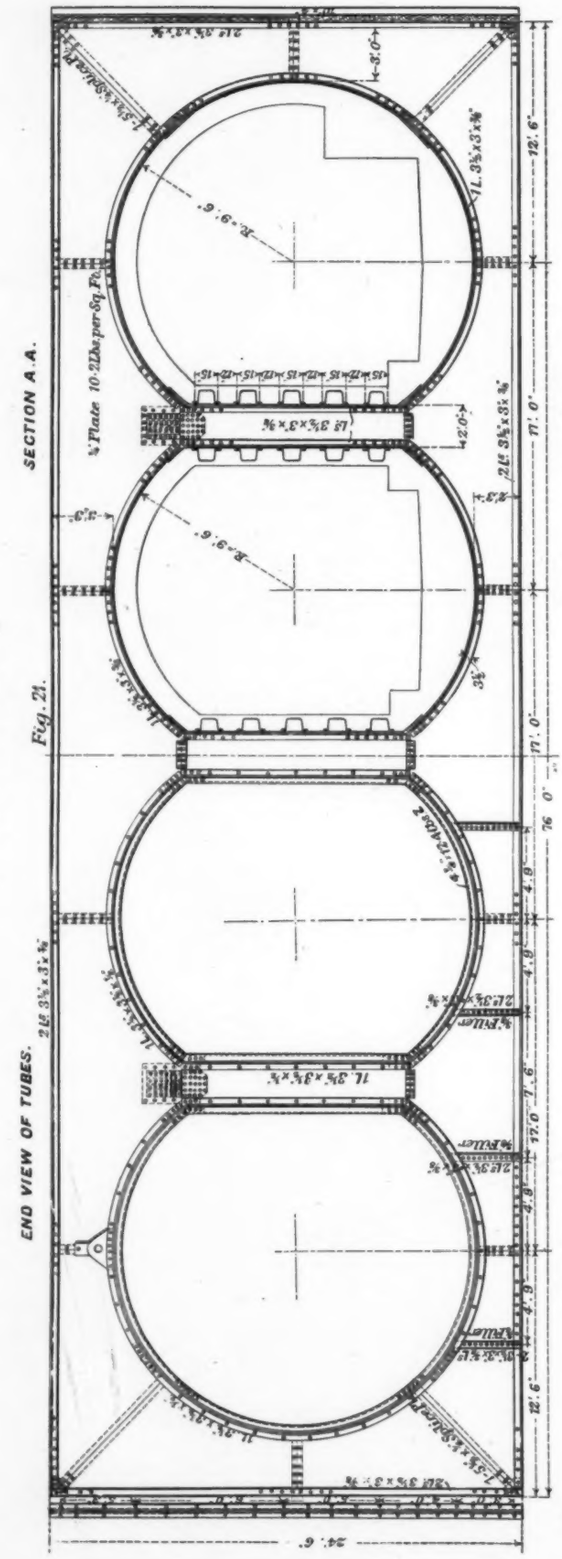
FIG. 19. ROCK-DRILLING PLANT.

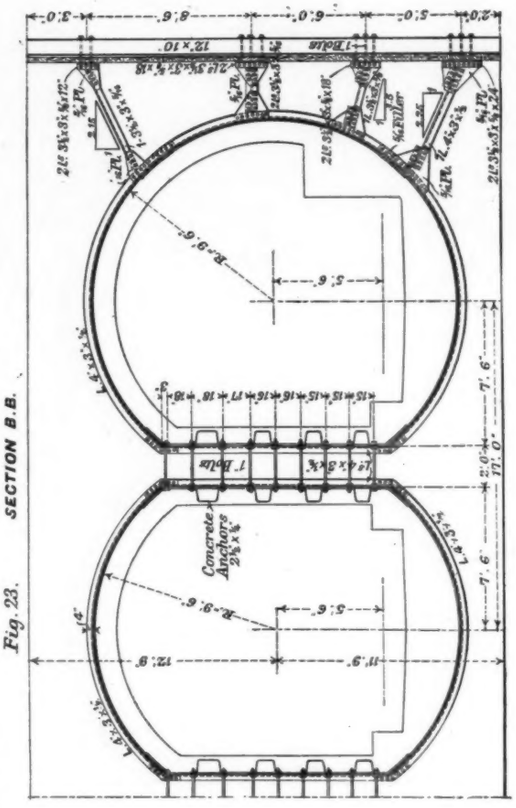
FIG. 20. ROCK BROUGHT UP BY DIPPER-DREDGE WITH 7-YARD BUCKET.

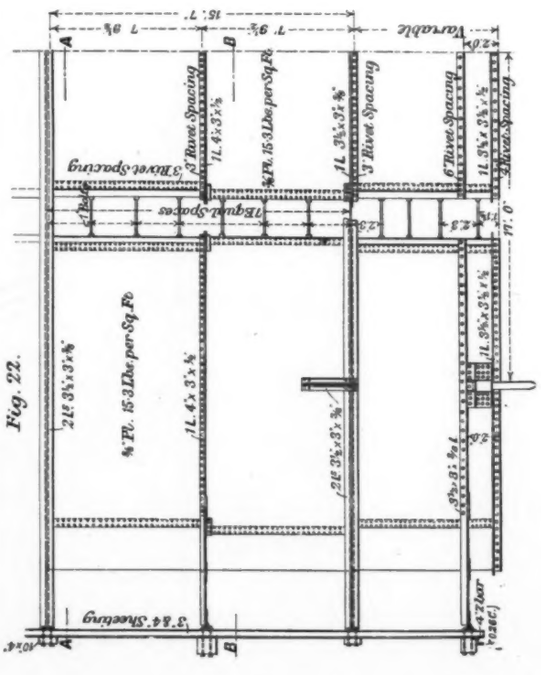
THE HARLEM RIVER SUBWAY TUNNEL, NEW YORK.

THE ARTHUR McMULLEN AND HOFF COMPANY, CONTRACTORS, NEW YORK.

(For Description, see Page 32.)







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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

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With Four One-Page Plates of the HARLEM RIVER SUBWAY TUNNEL, NEW YORK.

NOTICE OF MEETING.

THE SOCIETY OF CHEMICAL INDUSTRY.—Wednesday, Thursday and Friday, July 18 to 20, at Birmingham. Wednesday morning, Presidential Address. Wednesday afternoon (3 p.m. to 6 p.m.): (1) "Some Problems presented by Silica Bricks," by Professor W. G. Fearnsides. (2) "Refractory Materials," by Mr. Walter C. Hancock, B.A., F.I.C. (3) "Chemical Porcelain," by Mr. Henry Watkins. (4) "British Sources of Sand for Glass and Metallurgical Work," by Professor P. G. H. Boswell, A.R.C.Sc., D.I.C., D.Sc. (Lond.), F.G.S. Thursday morning (10 a.m. to 1 p.m.): (5) "Industrial Fuel from Gas Works," by Mr. E. W. Smith, M.Sc., F.I.C. (6) Calorific Value of Industrial Gaseous Fuel," by Mr. W. J. Pickering. (7) "Some Sources of Benzol and Toluol for High Explosives," by Mr. T. F. E. Rhead, M.Sc. (8) "Recent Developments in the Industrial Application of Town's Gas," by Mr. C. M. Walter, B.Sc. Thursday afternoon (2.30 p.m. to 5.30 p.m.)—Group I: (9) "Manufacture of Synthetic Nitrates by Electric Power," by Mr. E. K. Scott. (10) "Synthesis of Ammonia and its Oxidation to Nitric Acid," by Mr. Edward B. Maxted, Ph.D., B.Sc. (11) "Chemistry of Vulcanisation," by Mr. D. F. Twiss, D.Sc. (B'ham), B.Sc. (Lond.), F.I.C. (12) "The Scientific Needs of the Rubber Industry," by Mr. B. D. Porritt, M.Sc., F.I.C. Group II: A series of papers dealing with the metallurgical industries will be presented by the following gentlemen:—Professor T. Turner, Dr. H. W. Brownsdon, Mr. J. Kent Smith, Mr. J. E. Fletcher, Mr. J. H. Stansbie, B.Sc., F.I.C., Mr. F. Johnson, M.Sc., Mr. F. C. A. H. Lantaberry, M.Sc. Friday morning (10 a.m. to 1 p.m.): (13) "Organisation of Industrial Research," by Mr. H. W. Rowell. (14) "Scheme for Co-operative Industrial Research," by Mr. H. W. Rowell. (15) "Artificial Silk," by Mr. Leonard P. Wilson, B.Sc. (16) "Activated Sludge Process," by Mr. Edward Ardern, M.Sc. (17) "The Future of the Fine Chemical Industry," by Mr. Ernest W. Mann, B.Sc. (Lond.), F.I.C., Ph.C. Friday afternoon, visits to works.

NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal from 6d. to 8d. per copy. This increase dated from and including the issue of Friday, March 16. The change will not apply to unexpired subscriptions.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

ENGINEERING.

FRIDAY, JULY 13, 1917.

JOINT STANDING INDUSTRIAL COUNCILS.

THE Reconstruction Committee has referred to its Sub-Committee on Relations between Employers and Employed "to make and consider suggestions for securing a permanent improvement in the relations between employers and workmen, and to recommend means for securing that industrial conditions affecting the relations between employers and workmen shall be systematically reviewed by those concerned, with a view to improving conditions in the future." As an instalment of its work the sub-committee has presented an interim report recommending that Joint Standing Industrial Councils should be formed, to which in effect should be entrusted the supreme control of every organised industry and of every works that it includes. It is suggested that these councils, together with district councils and works committees to co-operate and be co-ordinated with them, should be composed of equal numbers of representatives of trade unions (on works' committees, of employees elected as may be agreed by the unions) and of employers' federations; and the Government is urged without delay to request these bodies to adopt measures for establishing such councils.

Such proposals for the control of industry are not new. They were developed, for example, very elaborately in what is known as the Garton Memorandum, published last autumn, and have given rise to much discussion in political and academic circles. So long as the discussion was confined within such limits, it was not a matter of immediate consequence for engineers to take an active part in it. Their hands were full enough already with the country's work. Now, however, that the Government is proposing to translate these schemes into administrative and, as is not obscurely implied in the report, ultimately into legislative action, engineering industries have a practical interest in them that can be no longer ignored. It is the stronger because, if such schemes became law or even accepted practice, they would impose on the trades concerned conditions of working that are neither immediately obvious from the terms of the proposals, nor are plainly avowed by their official supporters. They would subject those trades and every firm and man in them, workman or employer, unionist or non-unionist, to the final control of the trade unions.

This is by no means a mere reversion to pre-war conditions. Union shops were carried on before the war, in which non-unionists were not allowed to work; but side by side with them were free shops, in which no union test was enforced, and non-union shops, from which unionists were excluded. When the Government decided that to restrict the output of munitions should be made unlawful, it coupled its proposals with a guarantee that the suspension of trade union conditions during the war should not prejudice either employer or employed after it was over. By this guarantee the State is bound; and as it stands, the free shops and the non-union shops must resume their original freedom to admit non-unionists and exclude the union, while the union shops must revert to their original customs, except to such extent as the men in each shop may agree with their employers that they are to be varied.

It will be seen that the present proposals in effect wipe out the free and the non-union shops altogether. Although before the war the unionists in the engineering trades can have included no more than perhaps half the number of the non-unionists, the control of every individual shop, of every trade-district, and of every trade, is to lie in the hands of bodies composed half of representatives of the trade unions and the other half of those of employers' federations. The equal representation of unions and federations does not give equality of power. An employer has at stake the accumulated earnings and investments that represent the capital of the enterprise for which he is responsible, apart from his common interest with the men in its income for the time being, with which alone they are concerned. In addition he both has the keener sense that his training has taught him of the danger of contest in the face of external competition, and lacks the men's occasional incentive of thinking that it is time to take a holiday and get a bit of their own back out of their union subscriptions. By pressing their demands just up to the point at which the employer can afford better to concede than to fight, the unions would constantly have the opportunity of extorting from his necessities what they could not demand justly; and for this purpose they could at any time use the power to create a deadlock on whatever point might be in question.

The control is to extend to every branch of manufacture. Eleven heads are given in the report to illustrate but not to exhaust the list of the subjects with which the councils are to deal, and these include improvements of processes, machinery and organisation; matters in which, if management has any skill and any responsibility at all, it should have the final decision and give the benefit of its undiluted skill. They include, likewise, not only the decision of the standard wages, a natural subject for the consideration of such bodies if they exist, but also of piece-work rates, which clearly must or should vary from shop to shop according to its individual circumstances. No workman who is not a unionist and no employer who does not belong to the federation is to be represented on these councils; and no agreement at which councils, either national or district, may arrive may be varied even by a works committee in its own works. The whole trade in gross and in detail is to be bound hand and foot by these bodies. No employer is to be free to agree with his men to work under conditions that may suit both of them better than those of the councils, or even to adjust differences with them except on the lines that are prescribed to him and to them. Men are not even to have the right to modify pre-war customs in restraint of production. Such waiver, though by common consent it may be necessary for avoiding the ruin of a shop or an

(To face page 33.)

industry, is to be forbidden without the prior consent of the unions. The right to have these customs restored, guaranteed though it was to the men on whose behalf the unions purported to speak, is to be taken away from them, and to be vested, whether for use or for revision, in the small oligarchies by which trade unionists are controlled.

The justification that is usually put forward for proposals of this class is that without the assured mutual support that can be obtained only by rigid discipline and uniform action workmen are single sticks instead of a bundle, and can be broken readily by any firm against whom they are pitted. Doubtless this justification will be put forward again if the policy of the report is challenged. But it is now obsolete. Before the war many men knew that employers and employed had interests in common far greater than those in difference. To-day most men know it; and they know more. They know that the State has no less a concern than either employers or men in seeing that these common interests are respected; that the country after the war will stand or fall according to the fate of its great industries. This fate will be fortunate or disastrous according as all the parties to industry are doing their best or not; and employers cannot use their best skill in management if they cannot count on their men's best energies, nor their men, even if they were willing to do so, yield their best economic result if their work is not done and their lives lived in the best conditions. The energies of employers and employed must be united in each individual works, and be free and encouraged to develop individually, instead of being shackled by the conditions of a trade-wide control.

And therefore the functions that can be trusted safely to trade unions and federations have changed. As mutually consultative and co-operative bodies they have an indefinitely wide future, if they choose to play their part. Works committees, indeed, the direct means of communication between employer and employed, should be set up spontaneously in those works that would have them, leaving those that would not to take the consequences of their refusal; but national or district councils such as those proposed by the report, if they were set up as organs of conference and conciliation, might be invaluable adjuncts to any industry. If the trade union leaders themselves, many of them reasonable and extremely able men, would recognise that the country cannot afford to jeopardise its future living by leaving its essential industries at the mercy of civil strife, they could find in the deliberations and enquiries of such joint councils work fully as honourable as their present employment, and far more fruitful to the interests that they have at heart. But as mechanisms of control joint councils are now too late. A condition so important that it demands control and cannot be left to voluntary co-operation must henceforth be the State's business, not to be left to the hazard of negotiations. A condition that is of less importance may fairly and safely be left to be settled between the individual parties to each case when it arises; for the competition between works for the best men, a competition which in the impending struggle for the world's trade will be stronger than ever, will quickly teach wisdom to those employers who prefer getting the better of their men to getting the best out of them.

Yet, plain as these considerations are, they are not likely to satisfy those who have inspired the present proposals. We have assumed in their favour that they are conscious of no corrupt motive or sharp practice; that they have acted as they believe to be in the best interests of workmen. But this discussion of the subject would be culpably incomplete if it failed to point out that in their essentials these proposals are indistinguishable from an unscrupulous political manœuvre, against which engineers who do not wish their industry to be sacrificed to political ends will have to do more than protest. The truce that was proclaimed in party politics has unhappily not extended to industry. Month after month at the beginning of the war the Government stood by, and chose deliberately to permit the systematic under-production of munitions rather than coerce the constituents of their political friends. When finally, after ten months of restricted output, it took powers to stop this murderous outrage, it made a bargain very advantageous to almost all the workmen affected. The bargain was more than fair; but no one in times like these will grudge the benefit that most men have derived from the transaction, even though regretting that the gain did not extend to the most highly skilled. But having paid the price, and taken the powers of the Munitions Act in trust at last to secure weapons for its men, the Government betrayed its trust and was faithful only to its trade union policy. It continued to permit strikes and restriction of output and the rejection of women's labour, while to its knowledge, and on the public admission of the most prominent of its leaders, these atrocities were enabling the enemy to massacre our half-defenceless men, to perfect his defences, and indefinitely to prolong the war. Even now, after having exempted right and left from military service men whose trade union ticket was their only title to be called skilled, it is still endeavouring to define by negotiations with the unions the extent to which they will permit national needs to be satisfied. There has been talk of a Great Betrayal through the war having made pre-war conditions impossible. There has been and there will be no such betrayal. The Great Betrayal has been that of our dearest flesh and blood; and what the sub-committee proposes in its scheme of Joint Standing Industrial Councils is to entrust to the influences that have conspired in this betrayal for nearly three years the control of industry and the nation's future.

ENGINEERING ON THE RIVER TIGRIS.

THE despatch by Lieut.-General Sir Stanley Maude, K.C.B., Commander-in-Chief of the Mesopotamian Expeditionary Force, issued this week, is a pleasant antidote to the sad revelations in the report of the Commission appointed to inquire into the blunders connected with the previous phase of the campaign on the Tigris River. With General Maude's comprehensive review of the military operations we are not here concerned, nor have we thought it desirable to refer to the report of the Commission, but the occasion may be taken to indicate as completely as prudence dictates the splendid work done by the engineers associated with the operations, particularly at the base, and by the shipbuilders and engineers at home in the supply of the *matériel*. Amongst the reforms courageously and persistently advocated by Major (now Colonel) Carter, whose fearless advocacy of efficiency in the medical corps is one of the brightest spots in the gloomy picture painted by the Commission, was the provision of special hospital steamers for service on the Tigris River. Immediately on his return to this country he set out clearly the necessary requirements for such ships, and with these the naval architects for the India Office, Messrs. J. H. Biles and Co., have succeeded in producing a series of ships which admirably meet the case, and in the building of these Colonel Carter and Sir John Biles—and, since his appointment as Director of Inland Transport, Colonel Collinson—have, in their respective spheres, brought to bear a great experience. Not only was it necessary in the design to provide for the shallows, the tortuous channel and the rapid currents of the Tigris, but to ensure sufficient strength in the permanent structure and the temporary stiffening for the passage of the ships from this country to the East. The vessels are limited in length to 160 ft., and it was found that a beam of 30 ft. was necessary to ensure the light draught in association with the required displacement. The depth moulded is 6 ft., but there are four "flying" decks, so that, for the dimensions, very extensive accommodation is provided, while as regards the medical equipment nothing could be more complete.

General Maude, in his despatch, points out that the newly-formed Inland Water Transport Directorate had first to fill its ranks, and then to develop its organisation and provide for its many indispensable requirements, but "the *personnel*, making light of these very real obstacles to rapid progress, worked insistently, with the result that, night and day, an endless chain of river craft passed up and down the river, thereby ensuring the maintenance of the troops at the front." Near the mouth of the river an extensive area of swamp was converted into a shipbuilding and engineering factory, with an equipment surprising under the circumstances, and with huts for the workers and officers, a canteen, and all other desirable accessories. Here large barges are being built, ranging up to a length of 150 ft. by 35 ft. by 8 ft. The first of these was turned out within 16 days of the first plate being laid; in fact the first barge was ready almost simultaneously with the departure of the ship which imported the material. This success is the more surprising as the staff on this work is a very polyglot one, comprising Chinese, Egyptians and Europeans; in respect of language the only analogy is that of the workmen engaged on the Tower of Babel. The staff in the engine department is controlled by two officers, four non-commissioned officers and half a dozen sappers; all the others are native workers. Electric generators, air compressors, ammonia ice plant, and pumps, are all driven by oil engines. There is a well-equipped engineering repairing establishment and capacity for lifting loads of 500 tons. The officers have come from all parts of the world, and include four Scotchmen, all of whom have had experience in our Dominions, six Englishmen, most of whom also have had previous colonial experience, one Welshman and one Irishman. Experience is co-ordinated by conferences, and thus there is brought to bear on the tackling of problems the most effective lessons of many lands. Many things are done on which there is no guidance in technical books or journals. Good work, too, is done in the manufacture of pontoons for bridges and the construction of oil tanks, while girder work is freely imported, notably from India, being commandeered from all sorts of structural contracts.

Another department of engineering which is specially noteworthy is the development of the Basra harbour works and wharves, under the control of Sir George Buchanan. General Maude, too, points out that the responsibilities of the works directorate in connection with problems at the base and on the lines of communication have been very heavy, "but the many problems have been resolutely handled with that resourcefulness and success which is so characteristic of the Royal Engineers." Road-making, water supply, building and reclamation work at the base alone have reached vast dimensions and have demanded constant attention and thorough organisation.

FORTH AND CLYDE SHIP CANAL.

THE great European War has aroused fresh interest in this scheme, which was first brought before the public nearly thirty years ago. At that time Messrs. D. and C. Stevenson, MM.Inst.C.E., Edinburgh, advocated the route *via* Loch Lomond and Loch Long, as more recently described in our pages (see ENGINEERING, vol. lxxxvii, page 564), while Messrs. Crouch and Hogg, MM.Inst.C.E., Glasgow, after an examination of alternative schemes, reported in favour of what is known as the "Direct Route," following closely the valley through which the existing barge canal was constructed towards the end of the eighteenth century. At that time they recommended a canal with a summit level of 95 ft. above ordnance datum, involving a number of locks, to bring the cost within the sum on which it was believed it would be possible to earn a dividend from commercial traffic alone. Fig. 1 shows the ocean routes, with special reference to the termini of the canal.

The construction of H.M. Dockyard at Rosyth and the dangers revealed by great war demand that the whole question should be reconsidered from the national point of view, treating the revenue from commercial traffic simply as an important means of reducing the annual cost to the nation.

In 1890 it was proposed that the ship canal *via* the direct route should join the Clyde at Yoker, but since then there has been an enormous industrial development on the north bank of the Clyde, and the construction of the Rothesay Dock and its railway accesses make it now impossible to join at Yoker. After studying various alternative points of junction it is now considered that the best

would be at Clydebank, because the ground on the south side of the Clyde opposite the junction is not only available for the widening of the river, but most suitable in every way for docks and graving docks of the largest size and for a new town beyond the docks, while railway communication can easily be obtained.

In accordance with the Admiralty requirements the bottom width of the canal will be 148 ft., and the depth of water 40 ft. throughout, with regulating locks at each end. The depth of the Clyde is at present about 25 ft. at low water. While this depth will meantime restrict at low water the through traffic from the North Sea to the Atlantic, there would be no difficulty in further deepening a short section of the Clyde sufficiently to give access at all states of the tide to the proposed new docks and graving docks of the largest size on the south side of the river. Access to a battleship graving dock would thus be quite independent of the general deepening of the Clyde.

The comparative distances are as follow:—

	Miles.
Direct Route.	
Grangemouth to Clydebank	30.5
Loch Lomond Route.	
Grangemouth to Loch Lomond ...	36.2
Loch Lomond	12.8
Tarbet to Arrochar	1.8
Arrochar to Clydebank	34.7
Total	85.5

	Miles.
Grangemouth to the Cloch.	
By direct route	50.5
By Loch Lomond	69.3
Grangemouth to Clydebank.	
By direct route	30.5
By Loch Lomond	85.5

Fig. 2 shows the two routes.

Quite apart from the saving in distance by the direct route there would be a greater corresponding saving in time, as the direct route could be easily lighted so as to be as fully utilised by night as by day, while the Loch Lomond portion of the other route could not be so easily navigated by night.

Fig. 1.

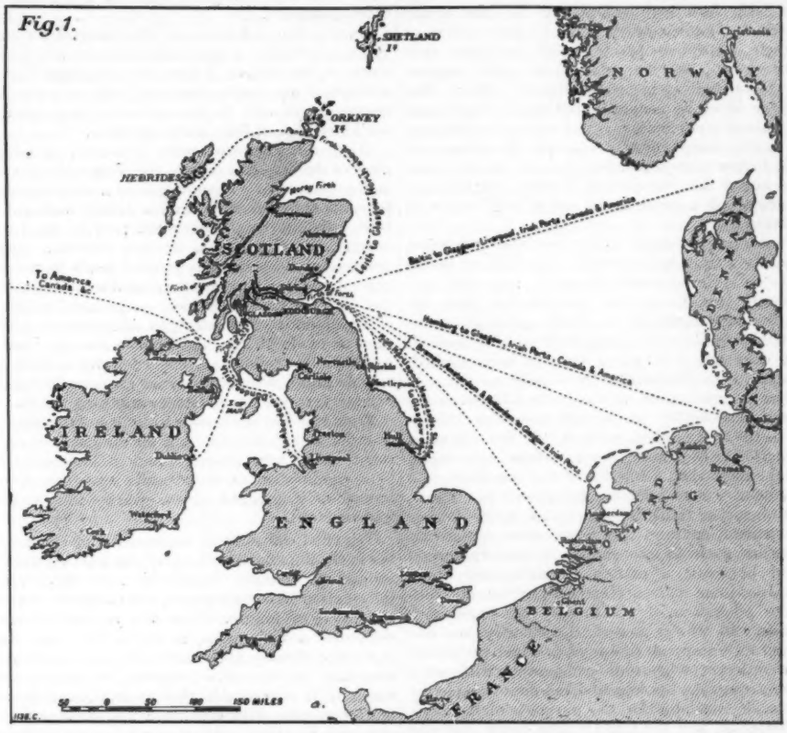
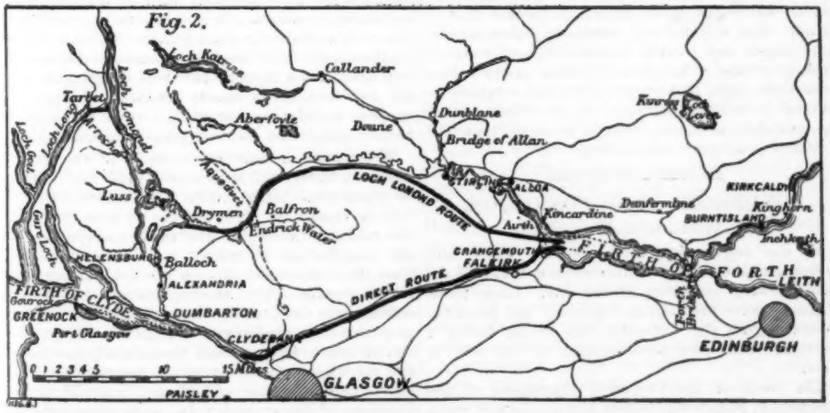


Fig. 2.



As regards through traffic, the saving in distance between New York and the Continental ports on the North Sea would be about 300 miles, and between Glasgow and the same ports nearly 500 miles. Various estimates have been made of the amount of shipping which would probably make use of a ship canal across Scotland and the annual revenue which would be derived therefrom. The revenue has been estimated at about 800,000*l.* per annum, but whatever may be its probable amount there can be no question that the revenue by the direct route would be considerably greater than by the Loch Lomond route.

As regards interference with the existing roads and railways on the direct route, these would be negotiated chiefly by fixed bridges, except at the Clydebank end, where it would be necessary to adopt swing bridges. It is not intended to abandon the existing canal, which now belongs to the Caledonian Railway Company.

The ship canal by the direct route would be practically at sea-level, while by the other route it would have to be at the level of Loch Lomond, which varies 5 ft. or 6 ft. in the course of the year, and is, on the average, about 20 ft. above high water in the River Clyde. It has been assumed that the water supply in Loch Lomond is inexhaustible, but that is not so, and it is contended that the abstraction of water from Loch Lomond for working the locks would very seriously affect the existing water supplies to the calico printing and Turkey red dyeing industries in the Vale of Leven. As regards the question of water supply, the direct route at sea-level, and therefore largely independent of fresh water supplies, is unquestionably greatly superior to the Loch Lomond route.

The locks will be double, one 900 ft. long by 100 ft. wide, with intermediate gates, and the other 400 ft. long by 50 ft. wide. There will only be one set of locks at Grangemouth and another at Clydebank. On the other hand, the Loch Lomond route is handicapped by the winter floods in Loch Lomond, which have been as high as 8½ ft. above the summer level of the loch, which is intended to be the summit level of the canal, and this will involve the use of regulating locks at the entrance to and exit from Loch Lomond and, in addition, two locks at Grangemouth and two at Arrochar at the head of Loch Long. The summit level of the Loch Lomond route is 27 ft. above low water in Loch Long and 31 ft. above low water in the Forth.

Several years ago estimates of cost were made, but since then the Admiralty requirements have been increased, and now the cost of all works has been enormously augmented as the result of the European War. At pre-war prices the cost of the ship canal on the direct route would have been about 25,000,000*l.* but, of course, at present war prices the cost would be considerably in excess of that sum.

The Admiralty will judge of the relative strategic values of the alternative routes and will, no doubt, attach importance to the fewer locks required on the direct route, but even assuming equal strategic value, the Treasury will undoubtedly be favourably impressed by the arguments of those who contend that the revenue from commercial traffic will be much greater on the direct route than on the Loch Lomond route.

THE MINISTRY OF MUNITIONS EXHIBITION OF WOMEN'S WORK.

THE Lord Mayor of Leeds opened at the City Art Gallery on the 9th inst. an exhibition illustrating the various types of work upon which women are employed in engineering and other industries on munitions of war, which will remain open until the 21st inst. The ceremony was attended by a large number of employers in the city and district and by Mr. Ben H. Morgan, the chief of the technical branch of the Ministry of Munitions, which is promoting the exhibition.

The exhibits include samples of work and official photographs of the operations in progress. They are classified in fourteen groups, dealing respectively with aircraft and other internal-combustion engines, motor lorries and accessories, steam engines, guns and components, small arms, gauges, drills and cutters, &c., metal aircraft fittings, aircraft woodwork, projectiles, general work, and optical munitions and glasswork. As in previous displays, the range of the samples and photographs covers practically the whole of manufacturing industry, and includes many operations demanding the highest skill. The present exhibition, however, adds an entirely new feature in the shape of a *catalogue raisonné* of the samples, giving for most of them information such as the way in which the exhibits have been made, the tools used, the extent of male skilled supervision, if any, the time allowed for each operation, and the like. Space will not allow a detailed description of the whole of the samples, about 1,000 in number, but a few examples may be quoted to show their range and the nature of the information that is given.

The group of aircraft engines includes details of

the Clerget, Hispano-Sueza, Le Rhône, R.A.F., Beardmore (160 h.p.), and Gnome types. Taking a specimen at random, we find a sample of the exhaust valve of the Clerget engine. The catalogue describes it as made in four operations. It is first turned all over in a Herbert No. 4 capstan lathe, the operation taking 20 minutes. The shank is then ground on a Churchill plain grinder, 4 in. by 34 in., to a limit of $\pm$ 0.0005 in., in 5 minutes; the head slotted in a Churchill No. 1 bench miller in 1¼ minutes; and the cotter hole cut in a Brown and Johnson No. 3 slot miller in 4 minutes. The work is all done by women under male supervision, women tool-setters being employed on the capstan lathes. The Gnome cam, again, is described as machined from the bar on Herbert No. 6 capstans. The diameter is first turned and faced and the bar parted off, the piece faced for grinding in a soft-jawed chuck, and the work bored, six at a time, in a jig. The limit for thickness to this stage is 0.05 mm., the standard time on premium bonus 27 minutes, and the machines are set up by men. The part so machined is then face-ground on a No. 1 Browne and Sharpe universal grinder with a magnetic chuck to a limit of $\pm$ 0.02 mm., the premium-bonus time being 12½ minutes, and one man supervising nine women.

The group of internal-combustion engines includes details of the 5-in. by 6-in. and 7½-in. by 8-in. "tank" (landship), the 6-cwt. National petrol tractor, and various motor-bus and motor-lorry engines and parts of the vehicles. Here, again, the work done is done wholly by women, sometimes also set up by them, and limits as close as 0.0005 in. are reached for machining as well as for grinding. The multiplicity of operations undertaken by women is seen even more strikingly in guns and gun components, notably in breech mechanisms and gun-sights, on which in one shop or another they seem to do practically every part of the work. In the manufacture of Lewis guns and other small arms an occasional exhibit is said to be made 80 per cent. to 90 per cent. by women; but with these rare exceptions women do the whole of the work, some of it running into over twenty operations and machines for a single part, each of which the catalogue specifies for most parts, with its time and other particulars.

In the groups of gauges, cutters, test-pieces, &c., plug-gauges are shown manufactured by women outright to a micrometer limit of 0.0003 in., and an imposing collection of spade cutters for shells up to 9.2 in., steel test-pieces of various patterns to 0.0001 in., milling cutters for pitch-gear cutting and many other purposes, twist drills, &c. The extent to which women's work is used seems to vary widely in different shops, but some of it is remarkable for the short experience that is found necessary for turning out serviceable and trustworthy work. Two or three weeks, for instance, are enough to enable a girl to learn to do the rough-turning and screw-cutting required on the production of screw gauges, and after a fortnight's shop experience girls are able to make screwing-dies complete except for backing-off and hardening.

Examples of what women are doing elsewhere than in the machine shop are seen in the groups of aircraft metal fittings and aircraft woodwork, where they show complete proficiency in welding, brazing, &c., and in both producing and assembling woodwork, from the slender ribs of a plane to the massive propellers, in addition to machining and fitting as seen in other groups. The group of projectiles is among the smallest in the exhibition, although—perhaps more correctly because—it is about the best-known achievement of women; but it includes an interesting series of cartridge cases and useful particulars of times, &c., on some bomb-parts. A considerable variety of general work is shown—chucks, gear, nuts, pneumatic tools, gear-pumps, &c.—and the optical section includes work of extraordinary fineness, both in glass and in metal. Thus the optical system of dial sights is made throughout by women, except for "a little touching-up by a highly skilled man"; the prisms for Barr and Stroud range-finders adjusted and balsamed in position by women; and the range dials and clinometer scales (shown in the "Guns" section) are graduated by them to a limit either of no measurable error or to a maximum tolerance of one second.

It is scarcely an exaggeration to say that the publication of the catalogue is an historical event in British industry, disclosing for the first time not only the variety of women's work, but definite information on the way in which it is achieved. The standards attained in different shops are doubtless widely different, alike in the extent to which women's work is used and the efficiency that they attain; and the publication of such information as is given in this catalogue—all the particulars of which have been furnished voluntarily by the works concerned—enables works to compare notes as to their respective practice, and to make such improvement as the comparison may suggest and their individual circumstances allow. The Ministry is to be congratulated on so useful and enlightened a publication; and we can neither pay it a higher compliment nor express the interest of the industry more accurately than to say that it is to be hoped that the present is only a preliminary instalment of a much more ample publication in the future.

We cannot, however, pass from this exhibition without referring again to the subject of our recent article on its predecessors (June 1, page 526) and expressing the hope that the dilution that the Ministry has shown by so many examples to be practicable in actual manufacture may be applied, as it does not yet appear to have been applied, throughout the industries that could use it. At present the application appears to be a bureaucratic process, operated by bureaucrats according, doubtless, to the best methods of their art; but whatever methods have been used, they have failed notoriously to make more than a fraction of the use that could be made of women's labour for urgent war needs, not to mention the help of industry in the future. The general, uniform and exhaustive application of results such as are shown in this exhibition should be made a matter of engineering direction, based on defined standards, which are subject to relaxation, if at all, only on engineering grounds. In women's work the country has discovered an untapped source of productive wealth of an order of magnitude comparable with what it possesses in man-power, and the more completely it is made available for the purposes of industry, the better off will the country and every man and woman be in the great industrial contest that is ahead. But the present situation makes a still more urgent call for the extended use of women's work in release of men; and neither political considerations nor bureaucratic practice should be allowed to interfere between the manufacturers of the country and the immediate duty that the Ministry's engineers owe to them.

CONDENSER TUBE CORROSION.

By WILLIAM RAMSAY, F.I.C.

In the engineering profession the cause and prevention of condenser tube corrosion is one of the most burning questions of the day. Large sums of money have been devoted publicly and privately to investigate the difficulty, but so far little, if anything, has been accomplished to the end in view.

The work of the Corrosion Committee of the Institute of Metals was looked forward to with great expectation, but it is to be regretted that the results published in the various reports are, so far as they go, of academic interest rather than of practical engineering value. While throwing some light on the mechanics of brass corrosion in general, from an engineering standpoint they only indicate, with close agreement to practice, the order of durability of tubes made from the various alloys in general use. Had the work taken a different course, one cannot but think that something of more immediate value to engineers might have been forthcoming.

Retubing a condenser is always a costly business, even after the tubes have done good service for what may be regarded as the natural period of their life, not uncommonly ten, fifteen or even twenty years; but unfortunately one is frequently faced with cases where they have broken down after a comparatively short period of use, often only a few weeks or months. This is a much more serious matter, and it is in just such cases as these where the Corrosion Committee has failed us. Again, unfortunately, this type of defect has been increasingly familiar during the past ten or fifteen years, a fact which has given rise to the opinion that the extra purity of the metals now employed is responsible for the trouble. But, on looking up analyses of condenser tubes over a period of twenty years, I find that there is no justification for such a suggestion. The alloys now used are, so far as purity is concerned, probably no better or worse than the older material.

Having been interested in this question for many years, and being exceptionally well situated for the study of the subject, it has been suggested that an account of my observations and some experimental results might add to the not very large total of our knowledge of this elusive problem.

When a breakdown occurs it is usual to hand a piece of the defective tube to the chemist for analysis and explanation. The analysis is a simple matter, but since the corroded metal has disappeared and the tube adjacent to the corroded part is, as a rule, normal, the explanation is more difficult. Again, analysis of the corrosion product leads to no conclusive result; it generally contains the metals of the alloy as basic chlorides, carbonates, oxides or even sulphates, together with adventitious matter such as oxide of iron and organic matter; and as much of this product is washed away in both the soluble and insoluble form, an examination of the residue very seldom points to anything useful.

From time to time I made a number of experiments in order to throw some light on the cause of corrosion; many were abortive, and in some cases the true significance of the results was not always immediately apparent, or was even contrary to what was expected.

The chief difficulty of experiments of this nature lies in the impossiblity of reproducing actual working conditions. Simple immersion tests may afford information on certain points, but can rarely indicate the cause of failure. This also applies to model condenser arrangements, in which the same water is circulated many thousands of times. Such water may lose its corrosive properties or, on the other hand, it is conceivable that it may even become more corrosive with continued use, so that results obtained by these methods must be accepted with certain reservations. One of my first experiments was with a condenser plant smaller than, but similar to, that used by the Corrosion Committee in their work, but after a few months this was abandoned, as it did not lead to conclusive results, and I do not propose to refer further to it. Other experiments will be mentioned in their proper sequence.

The nature of brass corrosion is, at the present moment, fairly well understood, and may shortly be described as being mainly, if not entirely, electrolytic in character. It is not my purpose to go into the micro-metallurgy of the various alloys used in the manufacture of tubes; it is sufficient to say that the commercial brasses are not homogeneous bodies, but are a kind of conglomerate, the various constituents of which have different solution pressures or electrolytic potentials. Even the 70 : 30 brass, which should theoretically have only one constituent, is not entirely homogeneous, but shows decided traces of different material at the junctions of the crystals; but even assuming that it is homogeneous, as will be shown later on, it soon acquires a condition which renders it "auto-corrosive"; by this term I mean that brass possesses within itself, or can acquire, the positive and negative elements necessary to form a galvanic couple, which, in sea water, results in corrosion.

Corrosion of a condenser tube may be said to commence from the moment it is put into use, and the extent to which it proceeds depends upon such factors as composition, time, temperature, water, and so on. The influence of these factors has been very ably investigated by Dr. Bengough and his co-workers, and published in their reports. I do not think that different sea waters can have a varying influence on the rate of corrosion, but estuary waters containing sewage, sand, &c., certainly have such an effect.

The effect of corrosion in condenser tubes is

varied. Copper and zinc may be removed uniformly from the surface, so that the walls become thinner and preserve the yellow colour of the brass, or, what is more commonly the case, zinc is dissolved out, leaving the copper or a copper-rich material as a coherent film, the original dimensions of the tube being nearly preserved. This action has been labelled with the rather cumbersome name of "dezincification," a term which has led to the idea that the solution of the zinc is chemical rather than electrolytic, but it is purely electrolytic. In the case of the 60 : 40 tubes the action takes place between the α and the β constituents and may proceed to completion, the tube retaining its original dimensions and, to the naked eye, presenting the appearance of a solid copper tube. On microscopical examination, however, it is seen to consist of coppery material preserving the form of the α constituent, the space previously occupied by the β being more or less filled by corrosion product, or possibly quite empty. I have in my possession a piece of 60 : 40 tube which has undergone this complete dezincification; the information which accompanied it was to the effect that it broke into short pieces when drawn from the condenser, and was so soft that it could be distorted between the finger and thumb, but on drying it became quite hard again. Apparently it was only held together by the interlocking skeleton of the α brass.

With 70 : 30 tubes and Admiralty alloy the action is probably somewhat different. Owing to some slight inequality in the composition—or, possibly, to a thin film of copper oxide, from which the tubes are rarely free, and which in contact with salt water is reduced to copper—the equilibrium of the brass becomes upset, and a more or less continuous film of copper results; electrolysis then takes place between the copper and the underlying or adjacent brass, resulting in a gradual concentration of copper. With these tubes dezincification is as a rule superficial, the more compact nature of the residual copper sealing off the metal underneath from further action. That the Admiralty alloy and the newer lead brass are more resistant is probably due to the more insoluble corrosion product being impacted in the porous copper residue.

But dezincification is not the simple process outlined above. If some of the copper goes into solution—and there is ample evidence that it does—it may be redeposited as metallic copper on the brass, an equivalent amount of zinc going into solution. I have proved that cuprous and cupric chlorides, oxide of copper, and, in fact, most copper compounds are capable of depositing metallic copper on brass. Less easily understood is the action of basic chloride of zinc. On painting tubes with this body and immersing them in warm sea water a distinct coppery stain results after some time. Dezincification may, therefore, be regarded as a normal process which, so long as it remains superficial, as in the case of the 70 : 30 brass, may even be protective.

But there is something more to be said about dezincification. If a portion of the coppery film be removed so as to expose the brass, it does not immediately become recoated with copper. A tube which had been dezinced to a depth of less than $\frac{1}{500}$ in. was taken, and a small patch about $\frac{1}{4}$ in. square removed with fine emery paper without appreciably altering the thickness of the tube. On immersing it in sea water kept warm the brass rapidly corroded at this point, until in about a month it was about $\frac{1}{32}$ in. deep; copper then gradually encroached on the bare brass and stopped the action. I will refer to this later on.

One of the commonest and perhaps the most serious of forms of corrosion is that which leaves the tube scored with more or less continuous and parallel lines, involving the whole or any part of the interior of the tube, often to such an extent that it has a fluted or reed-like appearance; finally, perforation occurs, or the tube splits along one of the lines of corrosion. This type of breakdown is most certainly due to a defect in the manufacture of the tubes. Castings made with a sand core are very liable to have spills, which may extend to a considerable depth in the metal, and which on boring out remain undetected. On drawing into tubes these spills become elongated into what are known as laminations, which may often be traced for a number of feet, in some cases almost through the thickness of the tube. Laminations are comparatively rare on the outside of tubes, since they are more readily detected there, and if present in the casting, it can be turned down until solid metal is reached. On sawing a laminated tube lengthwise the defects appear as shown in the photograph (Fig. 1, page 40), and might easily be mistaken for a mere discoloration of the metal. On flattening the tube, however, they open up, showing their true character. Fig. 2 is a photograph of such a flattened tube. These defects may occur as mere surface folds, or may penetrate the wall of the tube to any extent. On opening them up they are seen to be coated with oxide of copper, which, on immersing in sea water, is gradually reduced to the metallic state; and this is probably the initial stage of electrolytic corrosion. Sooner or later the corroded lamination breaks away, exposing fresh lines of yellow brass, and the action is concentrated at these places (see Fig. 7). The following experiment was carried out in order to test the truth of the above. An Admiralty tube which showed indications of a lamination was immersed in estuary water, which was changed almost every day over a period of more than two years, the containing flask being kept at a temperature of about 110 deg. to 150 deg. F. by means of an electric heater. After a few weeks the tube was completely coppered, and the suspected lamination showed unmistakable signs of opening out. In about six months it had corroded away to a measurable extent, and several other lines or laminations, which had not been suspected, showed themselves. The tube at present is scored with several lines exactly like the initial stage of the type of corrosion in question. Throughout the test it was noticed that bubbles of gas (air or CO_2, or both) adhered tenaciously to the laminations and the sharp edges of the tube, in fact these places appeared to act as nuclei for the gases to separate from the water, the bubbles actually forming there and not adhering by accidental contact. Under such a test the rate of corrosion was, of course, very slow, and had it been under actual working condenser conditions the total effect would probably have been exceeded in a few weeks. During the corrosion the lamination presented a varying appearance, at one time showing black lines, which would clear up to yellow brass or film over with copper through which minute specks of brass were visible, but at all times the action was greatest at the laminations and edges. It was this tube (Fig. 3) from which the copper patch was removed to which I have previously referred. It is claimed for tubes made from solid castings in which the bore is either drilled or is pierced by hydraulic pressure that laminations do not occur, and that they are not liable to corrosion. The latter part of the claim is possibly too sweeping, but it is reasonable to expect that they will at least be free from reeding. I have no personal experience with these tubes, but I am informed that they go a long way towards solving this particular difficulty.

Another manufacturing defect is responsible for the occurrence of isolated holes in what may otherwise be perfect tubes. In the drawing process small angular fragments of metal are sometimes curled up and nearly detached from the tube, and in subsequent passes are either pressed back into their original position or are completely broken away, leaving a hole. These defects are usually small, but may be relatively deep, and perforation rapidly occurs at such spots when the tube is put into use.

Many new tubes which I have examined have shown minute holes or pores filled with a black material and surrounded with a copper-coloured zone; it would almost appear as if corrosion had already started, and I cannot but think that these points will prove active corrosion centres.

Another kind of corrosion which one occasionally comes across, and which is not to be confounded with the last type, also makes itself manifest as isolated holes or patches. In the present case the holes always lie along the bottom of the tube and never on the sides or top. The fact that certain spots only are attacked suggests what is known as local action, since, if the tube is uniform in composition, there is no reason why the corrosion should select any particular spot; but analysis of the metal underlying the defects never revealed any notable difference from the normal alloy sufficient to account for such action. Another possibility was that some foreign body which could form a galvanic couple with the brass had gained access to the tube and set up corrosion. This hypothesis was strengthened by the discovery of iron in the insides of tubes which had broken down after a very short run of work. On opening up the tubes it was found that the whole of the interiors were coated with a thick even deposit of ferric hydrate, which at certain spots along the bottom was perceptibly thicker; and under each of these spots small fragments of iron or magnetic oxide were found, each fragment being in the centre of a corroded pit. It is important to note that in every case it was the bottom of the tube which was affected. This experience recalls a set of experiments which I carried out some twelve years ago, the results of which seemed at variance to theory.

1. A clean, bright Admiralty tube was fitted up in the well-known form of a Liebig's condenser, the outer jacket, through which salt water circulated, being of glass, so that the action, if any, could be observed. About the middle of the tube a patch of zinc was electro-deposited, the idea being that it would preserve the tube from corrosion. Steam and circulating water were maintained at such a rate that the steam was completely condensed and the circulating water raised about 10 deg. C. After about 60 hours' intermittent run the zinc became almost black and then gradually turned reddish brown, at the same time the tube lost its brightness and showed signs of etching near the zinc. On removing for examination it was found that the zinc had quite disappeared, and its place taken by spongy copper, at the same time the brass in the immediate neighbourhood was superficially corroded to a slight extent. It was clear that copper had gone into solution and had been reprecipitated on the zinc, and so far from protecting the brass from corrosion it had actually initiated it, or apparently so.

2. A similiar tube had the point of a steel needle driven into it, and then broken off flush with the tube. This was fitted into the same condenser arrangement and the water and steam conditions kept as before. After about 90 hours' run chlorine was found in the condensed water, and on inspection it was found that the needle point had disappeared, and the hole, which was surrounded by a copper-coloured zone, was now large enough to pass the thicker shank of the needle.

3. A helical coil of steel wire was sprung on to another tube and submitted to the same action. After about 120 hours' run it was removed for examination. A distinct print of copper was found marking the position of the coil, which also showed traces of copper where it was in contact with the tube.

4. In a similar test pieces of clean gas carbon were wedged into the water space so as to be in contact with the tube. Within 16 hours the points of contact were surrounded by a coppered area, and in about three days the brass was measurably corroded at these points. The same experiment carried out with common coke gave similar results, but possibly took a longer time.

5. A spot of lead was fluxed on to a tube and filed nearly flush. The whole was thoroughly cleaned and anchored in a pool in the Mersey, near low-water mark, and observations made frequently. A green film gradually formed round the lead, and eventually spread over the whole tube. After a period of about three months the tube was corroded to a measurable extent just at the junction of the lead and brass; but before another observation could be made the tube disappeared.

It is rather remarkable that metals such as iron, zinc and lead, which are electro + to brass, should behave in this manner. The action is probably a secondary effect due to copper being redeposited on the foreign metal. In this connection it is noteworthy that magnetic oxide of iron, or metallic iron coated with this oxide, is sometimes electro + with reference to brass and at other times electro —. The reason for this erratic behaviour is yet to be

discovered. A form of corrosion of which I have definitely traced the cause is that which attacks the inlet ends for a few inches immediately beyond the tube plate. Here the cold circulating water, on becoming warm, deposits its dissolved gases; the part in the tube plate being kept cool, escapes this particular action, but just beyond this bubbles of CO_2 and air adhere to the tube, causing round each a ring of corrosion which eventually takes the form of a horseshoe, the open ends of which point in the direction of the water flow. This type of defect is most certainly due to the main condenser being used in harbour for the auxiliary machinery, when the smaller volume of steam does not necessitate the full-power circulation, and the friction of the water is insufficient to sweep away the deposited gases. Where an auxiliary condenser is used for port service this defect is obviated. Several rivers and harbours, and canals especially, have an evil reputation in this respect, all being more or less foul with sewage, while those with a good tidal scour are less objectionable. The accelerating effect of sewage, CO_2 and ammonia is well known.

Fig. 4, page 40, is a photograph of an opened-out tube which has suffered from this type of corrosion. It will be noticed that although the part in the tube plate is corroded it has escaped the typical horseshoe action. The vessel from which this tube was taken was known to berth in a very dirty harbour. Dezincification is general all over the tube, and in the middle of each horseshoe, but where the corrosion is severe the brass remains yellow. This seems to point to electrolysis between the separated copper and the brass.

There is another type of corrosion which affects the ends of the tubes and which may be found in any part of the condensers, and may occur singly or in groups. The extreme ends of the tubes are eaten away in the ferrules, which also may be involved; and in this case a curious accommodation between tube and ferrule often takes place, the more corroded part of the one fitting into the less affected part of the other, almost as if the action ceased when the pressure between the two had been relieved. This is most probably the case, since in cases of this type I have almost always observed that the tubes had been crushed or distorted by the ferrule. Physical condition as a factor in brass corrosion is fairly well established, and this seems a case which meets this theory. A condenser is generally tubed by several men, each taking a certain section or group of tubes, and it is not unlikely that one worker may have exerted such force as to bruise his tubes. This probably explains why such corroded ends generally occur in groups. So far as my experience goes the defect does not recur on the tubes being replaced. Fig. 5 is a typical case in which both the crushing and the corrosion can be observed.

Some time ago my attention was directed to a case of breakdown in a number of tubes of the non-drip type. These tubes have a longitudinal furrow running along the top, except at the ends where they enter the tube plate. The section is approximately shown in Fig. 6. All the tubes were badly corroded and holed in the position shown in black. As the metal must have been severely strained in the process of grooving and the corrosion was entirely confined to this locality, this would seem a definite case of corrosion due to difference of physical condition. Had the tubes been annealed after finishing it is improbable that this particular defect would have appeared. The great difficulty to a proper understanding of "physical" corrosion is the minute electro-motive force which is called into play, but it must be remembered that the time factor in such cases is a large and dominating one. The behaviour of hard and soft brass in an electrolyte is very erratic. The direction of the current so generated varies in an extraordinary manner; sometimes the hard brass is positive and at others negative, apparently due to polarisation and the condition of the electrode surfaces. The current generated is never very large, in the cold 2.5 to 5 millivolts. Bubbling air or CO_2 increases the effect, but unless fresh electrolyte is continuously supplied the current falls off very rapidly. Such small currents cannot immediately have an appreciable corrosive effect; but where the conditions are favourable—as in a condenser, where the galvanic elements are in close metallic continuity and the resistance and polarisation practically nil—the time factor becomes important. The E.M.F. from copper-brass is appreciably higher and becomes of significance in the consideration of electrolysis between dezincified surfaces and bare brass.

To my mind the most interesting, and at the same time the most puzzling, problem is the case where tubes are practically perfect after years of service. I have examined tubes drawn for inspection after eight to ten years' use, which, except for dirt and slight oxidation, have been almost as good as new. Analysis and microscopical examination disclose no reason for this, and whatever the influence may be, it is something quite apart from the metal of the tube, for such tubes respond to artificial corrosion tests just as readily as normal tubes. We are quite in the dark as to the reason for this phenomenon, and any light on the cause would be of immense value both theoretically and practically.

The prevention of condenser tube waste is almost as vexed a question as the cause. The circumstances governing corrosion are so varied and numerous, that what may be found effective in one case might utterly fail in others. Tinning the tubes, provided it is well carried out, seems to add life in many cases, while in others it would almost have appeared to accelerate the breakdown. Zinc protectors in the water ends may have some slight influence over a limited area and time, but as a rule the corrosion of the zinc under such circumstances can be traced to local action rather than to circuit action between the zinc and the surfaces to be protected. The settling of zinc corrosion product in the tubes is, in fact, not unlikely to defeat the object in view. Iron, either as plates or as the material of the water ends, appears to have a favourable influence on the life of the tubes, but how long it remains active is problematic.

These crude methods of opposing a slightly greater E.M.F. have been improved upon in the Cumberland and similar processes with what appears to be success, but, in my opinion, the safer and more satisfactory method would be to replace brass by one of the more resistant alloys which are now available. The initial cost is, of course, higher, but the increased life and relatively higher scrap value of alloys, such as cupro-nickel, renders this drawback more apparent than real. The ease with which brass lends itself to casting, machining and general working no doubt accounts for its use in many situations where other alloys, or even iron or steel, would be of greater advantage as regards corrosion. If designers would only accept the fact that under certain circumstances it is the nature of brass to corrode more or less rapidly in sea water, a great deal of annoyance and expense might be avoided. It is useful to remember that the higher the percentage of zinc in a brass the more easily it is corroded, and that air, CO_2, ammonia and sewage in the water hasten the action, especially in the presence of heat.

The practice of cleaning tubes by acids, alkalies, or some of the secret nostrums which are on the market, is questionable. If the vacuum is good and the corrosion product a thin, firmly adhering scale, I do not think it should be disturbed, since it is more likely to be protective than otherwise. On the other hand, if the tubes are choked to such an extent that the efficiency of the condenser suffers, there appears to be no other remedy than to clean them, but in any case if the deposit can be removed by a high-pressure water jet, or by brushing, this is undoubtedly better than applying chemicals.

Boiling out the steam space of a condenser with alkalies is a practice for which some engineers have an obsession. In turbine sets, where the only oil which can reach the condenser comes from the reciprocating auxiliary machinery, this seems hardly necessary, more especially since the modern tendency is to reduce cylinder lubrication to a minimum, and the oils used are mineral hydrocarbons, on which soda has no action beyond a possible slight emulsifying effect. A slight film of mineral oil can do no harm, and I have even suspected this as the protective influence on those tubes which resist corrosion, such tubes as I have examined having had a slight greasy coating on the inside.

The steam side of tubes rarely corrodes, but when it does the cause is usually obvious. It is a fact, however, that when a condenser has been laid off, or where air enters with the steam, the condensed water always shows traces of soluble copper for some little time after. This may be the origin of the trace of copper which is nearly always found in boiler deposits, although it might equally well be derived from the boiler mountings. It is rather a coincidence, however, that old engineers synchronise the first serious boiler corrosion with the introduction of the surface condenser.

In conclusion, I wish briefly to refer to the common idea that leakages from electric lighting circuits are accountable for condenser tube corrosion. That such cases have occurred is possibly correct, but in a steamship the free paths open to vagrant currents are so numerous that electrolytic conditions are practically non-existent. Even were such leakage directly through the condenser it would be conducted by the metal rather than through the water. Most of the cases which have been ascribed to stray currents must be attributed to quite other causes.

A precise knowledge of the inner mechanism of brass corrosion will be of great value to engineers and metallurgists alike, but as the present difficulty is not the slow natural decay of the tube in salt water but the extraordinarily rapid local breakdown, I cannot help thinking that careful and intelligent observation of actual cases will lead to more useful information than laboratory experiments.

INDUSTRIAL NOTES.

THE Minister of Munitions desires to call the attention of the public to the fact that under the Defence of the Realm Acts and Regulations no person is allowed to sell, purchase, hire or loan, or send on approval, any new or second-hand machine tool, without the permission in writing of the Ministry of Munitions.

Applications from intending purchasers should be addressed in the first instance to the executive officers of the Area Clearing Houses, the addresses of which can be obtained by application to the Central Clearing House, Charing Cross Building, London, W.C. 2.

Applications for permission to sell should be addressed to the Machine Tool Department, Charing Cross Building, Villiers-street, Strand, W.C. 2.

Special steps have been taken by the Government to maintain the speedy settlement of differences referred to the Committee on Production under the Munitions of War Acts. The following additional appointments to the committee have been made by the Prime Minister: Mr. W. W. Mackenzie, K.C. (chairman); Mr. J. W. White (employers' representative); Mr. W. Mosses (workmen's representative).

This enlargement of the Committee on Production increases the number of members to nine, and will enable three sections of the committee to sit simultaneously, under the chairmanship of Sir David Harrel, Sir George Gibb, and Mr. Mackenzie, respectively; it will also enable the settlement of differences to be effected with the minimum of delay.

We read in the journal *La Métallurgie* that the labour questions are practically all settled throughout France, there being only a few points in suspense here and there. The commission for distributing labour—a commission consisting of the right type of persons, who know the works and who act reasonably and equitably—continues its action in the various industrial regions one after the other. Its decisions are far from having the fantastic character of some taken by a certain military commission, which led to most singular consequences in some districts. Female labour continues to develop and to give interesting results. The following figures are given: 44,860 establishments occupy 1,512,798 workpeople, as against 1,238,623 at the commencement of 1916, equal to 98 per cent. of the normal total. Since 24 per cent. of the men are mobilised, the figures show the aid which France is receiving from foreign and female labour. In metallurgical works the women number 14 per cent. to 30 per cent. of the works total staff.

The same journal says that in view of the approaching termination of all munition work, every establishment should start now to find a new orientation for its activities and not wait until peace is proclaimed. This, moreover, is a necessity from the social point of view, so as not to throw idle the large numbers of present munition workers. It is the duty of Govern-

ment to direct the establishments in the transition, with the object of insuring peace at home by obtaining work for the whole community.

According to the Central News, an appeal for stronger industrial combination, signed by Mr. Arthur Henderson, secretary of the Labour party, and Mr. C. W. Bowerman, secretary of the Trade Unions Congress, and endorsed by the executive members of each organisation, is about to be issued to the trade union movement. It states that as the war nears a close the need for stronger industrial combination becomes more and more urgent, and the cause of Labour representation in politics more and more insistent. Progress is at present being made in the direction of co-ordinating the work of the Trade Unions Congress and the Labour party.

Speaking at Manchester last Friday, with reference to the great need there was for guns and shells, Sir L. Worthington Evans, M.P., one of the Parliamentary Secretaries of the Ministry of Munitions, said that as a result of the recent strike in the engineering trade several hundreds of guns were irrevocably lost to the Army. One man's grievance, he added, no matter how just, was almost insignificant compared with the result of stopping the whole train of war work. In the last offensive in France more shells were fired than in the eighteen weeks of the Somme offensive. Of one type of shell alone half a million were fired in one week.

The Press Bureau report of the speech made by the Premier at the secret session of the House of Commons on Monday last, with reference to Saturday's German air raid, contains a statement to the effect that "we should have been far better off at this moment but for the strike in April last, which lost us between 150 and 200 aeroplanes."

On Saturday evening, the 7th inst., the members of the Northfield branch of the Amalgamated Society of Engineers held their first annual social meeting. In introducing Mr. Herbert Austin as chairman Mr. J. J. Bell made reference to the pre-war conditions which existed between employers and trade unionists, stating that in the past employers were looked upon as enemies; he hoped, however, that the social meeting in question, with their employer as chairman, would form a precedent for similar meetings between trade unionists and employers all over England. "Our greatest enemy," added Mr. Bell, "was not the employer, but the middle man, who maintained friction between the employer and the worker." He hoped the action of the Northfield branch would serve as an example to be followed by all the branches of the Amalgamated Society of Engineers, as being one destined in the highest possible degree to make for the furtherance of cordial relations between employers and employed. In calling upon Mr. Austin to preside at the meeting Mr. Bell said that no man had done more for his country in this awful war than their chairman and he expressed the hope that before long Government would recognise the fact.

In the course of an interview which he had recently with a representative of *The Observer*, Lord Leverhulme is reported to have stated that the war had broadened our horizon, had given us new points of view, and had introduced radical changes into our social, industrial and commercial systems. The most important of these changes, and, in particular, those affecting the general standard of wages and living, would undoubtedly be permanent, and probably progressive. Although the advent of peace would witness the abrupt closing of many wide avenues of employment—munition factories and the like—which now afforded a profitable outlet for the energy of many thousands of unskilled workers, the essential fact to be remembered was that the high scale of pay these workers were receiving, a scale considerably above that of their pre-war earnings, had introduced into our industrial and social system not only a higher standard of wage, but also a higher standard of living and comfort.

The wastage of war would doubtless cause the permanent employment of an increased number of women; the determination of their sphere and remuneration were problems that would have to be solved.

Lord Leverhulme added that it would be necessary for labour, in his view, to be granted in future a direct, personal and equitable share in the profits of an enterprise in which it was engaged, in addition to its ordinary wage; in this connection he further stated that he had more faith in co-partnership than in profit-sharing. There were striking exceptions, but as a rule profit-sharing too often began and ended with a bonus, the amount of which was entirely dependent upon the goodwill, generosity or philanthropic instincts of the employer. In the case of co-partnership, the worker acquired a specific personal interest in the business, not a controlling power, but an interest which might increase year by year, so that by exerting his energy, intelligence and zeal to promote the concern's prosperity he was both receiving immediate advantages as a co-partner and helping to ensure prospective additional advantages for himself in years to come.

He also advocated the adoption of a six-hour working day. While the mechanical machine could run for 12 hours a day instead of eight, the human machine—if he might use the term—would consist of two shifts, each working six hours. He believed that the human machine would do as much in six hours as in eight, except in a few industries where exceptional conditions prevailed, while the extra hours worked by the mechanical machine would enable such an increased output to be obtained as would ensure the possibility of the same wages being paid to the human machine for six as were now paid for eight hours' work.

The series of exhibitions of women's work which is being given by the Technical Section of the Labour Supply Department, Ministry of Munitions, is continued this week and next by an exhibition in the City Art Gallery, Leeds. The Leeds exhibition is more extensive than its predecessors at Bristol, London and other towns, and its value is enhanced by a considerable amount of practical information which is conveyed by the majority of specimens. We deal with the subject in an article in the present issue.

Mr. F. G. Kellaway, Parliamentary Secretary to the Ministry of Munitions, speaking last Sunday at a meeting of the Allied Engineering Trades, Luton, said he was confident that once the workmen realised that by allowing dilution of labour on private work victory would be secured at an earlier date than would otherwise be the case, and that the proposal was made in the interest alone of the country, they readily would make the sacrifice the Government asked of them. If the people were told fully what the facts were which led the Government to any particular course of action, and satisfied their intelligent interest, he thought there was no demand which they need be afraid of making. Thanks to the devoted efforts of the British munition workers, he added, our gunners had this year been able to hurl against the German positions a mass of shell far exceeding any previous records. In spite of this fact our ammunition reserves had practically been unaffected both in France and in this country, for the production had more than kept pace with the expenditure of shells. Our total output during the third year of the war had been twenty times the output during the first year, and if he was asked to justify the dilution of labour he pointed to these facts as an eloquent testimony. Every gun and every shell placed at the disposal of our armies meant the weakening of the German position and greater strength and protection for our men. The demand for certain types of skilled labour was far greater than the supply, and was growing. The proposal of the Government was, under certain conditions, and with rigid safeguards, to allow dilution of labour on private work in order to bring a proportion of the skilled men now engaged on private work on to war work in shipyards and agricultural implement work, and also for the production of aeroplanes. He hoped the Government would be permitted to adopt what he believed would be its least objectionable alternative, and by dilution of labour in certain industries maintain the production at the highest level possible having regard to war conditions. Labour would be safeguarded in the conditions which were to be imposed in the proposals of the Government.

In order to facilitate the transfer of labour to important work, arrangements have now been made whereby workpeople proceeding to work of national importance, on which they have been placed through an Employment Exchange of the Ministry of Labour, will be provided with a railway warrant to enable them to travel at a reduced rate. The reduced rate is five-eighths of the ordinary fares, that is, of the fares in operation before January 1, 1917, without the 50 per cent. increase. The reduced rates will thus be considerably less than half of the full rates with the 50 per cent. increase.

NEW SHIPYARDS IN SCANDINAVIA—At Norrköping, Sweden, a new yard is about to be constructed where the Motala river enters Breviken. Two slips are already so far completed that the keel of the first vessel can be laid, a vessel of 725 tons deadweight. A shed will be built over the slip, so that work can proceed in all weathers. In the first instance cargo motor-boats of moderate dimensions are to be built, but the intention is to undertake heavier work by degrees; a floating dock for good-sized vessels will also be constructed. It has been decided to start a new yard also at Korsör, Denmark, specially with a view to the building of wooden vessels, both on contract and for own account on speculation. Three slips will be erected, and orders have already been received.

ENGINEERS AND THE ROYAL NAVY.

TO THE EDITOR OF ENGINEERING.

SIR,—Owing to the dearth of engineers for the Imperial Navy the Admiralty has been reduced to the doubtful expedient of advertising for young engineers who will be given the rank of engineer-lieutenant or sub-lieutenant (temporary) and the promise is held out that a proportion of those joining will be absorbed into the permanent list of the active service officers.

In spite of the fact that over 200 temporary engineer-lieutenants and sub-lieutenants have been entered for naval duties since the beginning of the war, the cry is still for more. How much the ill-conceived scheme that scrapped Keyham College and introduced the specialisation of the Osborne-trained officer for engineering duties has to do with the dearth of naval engineer officers is not difficult to determine, and that it is one of the causes which has created this shortage goes without saying. There was pointed out in your pages, at the time when the new scheme of training naval officers was mooted, the underlying national danger that lay in that innovation. As a proof that your prophecies were correct it is only necessary to mention the fact that the current Navy List shows only 31 Osborne-trained officers who have specialised in engineering. In other words, the scheme is as dead as Queen Anne, and now, when the country is plunged in a great war, the Admiralty has to search in the highways and byways for efficiently trained engineers, and in highways and byways that have already been gleaned by the Army authorities, to say nothing of what the Admiralty has already done in the same direction in securing the 200 odd officers already referred to. It is not the purpose of the present writer to flog a dead donkey by stating more about the ill-starred scheme of common entry and common training of the future naval officer, further than to state that the putative father of the scheme—a great Admiral—meant well; the pity is that he held naval engineering so cheaply and its professors of so little account. He was wrong; but when men holding great national administrative posts err, the nation, and not the individuals who are guilty, pays the penalty for their mistakes and blunders.

I am more than doubtful whether the Admiralty will succeed in enlisting the right type of young engineer for naval duties, as the service requires its followers to be many-sided and eminently adaptable to its peculiar ways. As already stated, the field from which these young men may be gathered has been well gleaned, and only those who are now engaged in some kind of national work can be left. The physically unfit do not count. One is therefore tempted to ask why the Admiralty has such a predilection for outside entries for commissioned rank when it already possesses matured men who are fully acquainted with all the kinks of naval life and who have proved themselves, in and out, as being highly capable marine engineers. I refer to the engine-room artificers and their branches, such as artificer engineers, chief artificer engineers and mates (E) who have risen from the ranks of the engine-room artificers. There are many chief engine-room artificers (each destroyer carries one) who are doing senior engineer's duties in vessels that have an indicated horse-power of over 33,000. Chief and artificer engineers are the engineers in sole charge of the motive power of vessels that are up to the power stated, so surely, from the ranks of these the Admiralty might have found many more than they have already selected for commissioned rank. It can be urged, I know, with some force, that these men are practically irreplaceable in the jobs they are now filling, but if that be conceded it is not difficult to understand the irritation and chagrin occasioned to these people by the bringing in of men from outside sources who are given superior rank and placed in authority over men who have given years of their lives in getting seasoned to the Navy's methods and all its requirements. I am aware that within the past few months 32 special promotions of chief and artificer engineers to engineer-lieutenants have been made. The Navy List also tells me that since war commenced 80 artificer engineers and engine-room artificers have been promoted to mates (E), but the two added together are less, by about one-half, than the number of temporary commissions which have been given to civilians. There is a nasty sting in all this, and the smart occasioned by it does not conduce to the smooth working of the naval machine. Let the Admiralty take its courage into both hands by allowing its charity to begin at home, and so give the engine-room artificer branch a fairer chance and a wider scope for its undoubted abilities and activities.

It is easy to imagine an astute Parliamentary spokesman for the Admiralty making out a plausible case against further promotions being given to the class in question, such as the usefulness of these men in the niches which they now fill, and against the denuding of the junior branch—the working engineers—whilst the war lasts. To this we would reply: There are now thousands of engine-room artificers who have joined the Navy for the period of the war only, and given more tempting conditions than now exist for joining for continuous service, hundreds would do so. So the nucleus exists for a war and post-war period, even assuming that the training establishments fail to make up wastage. Amongst the tempting conditions I place first and foremost, that of pay. When it is stated that the starting rate of pay of an engine-room artificer is only 5*s.* 6*d.* per day, it is not surprising if the right kind of man is not always ready to listen to the tempter who inveigles men into the Navy in times of peace. This rate of pay was established in the year 1883—thirty-four years ago—and not one farthing has been added to it since. This pay, compared with the rates obtaining in the engineering trades, is a positive scandal, and in many subtle ways it acts and

reacts upon the full efficiency of the service. Level up the pay to even the pre-war rate in the trades from which the engine-room artificers are drawn, when there will be no difficulty in obtaining recruits for long service in the Royal Navy. Higher pay—this is long overdue—coupled with a reasonable prospect of promotion at an early age for the fittest men, will solve one of the long-standing difficulties on the *personnel* side of naval engineering.

In conclusion: I of course only profess to have hurriedly skimmed over some of the points in connection with the junior, or ranker, branch of naval engineers. Naval nomenclature, in so far as it applies to the *personnel*, is difficult for the layman to understand. The term "engine-room artificer" applies to the naval rating who is precisely on a par, in all respects, with the engineer in the mercantile marine. Why he is not called by this simple name puzzles those who have given study to the subject. Simply stated, engineers differ only in degrees of ability. Status is determined only by such differentiation and by nothing else. Powerful vessels of war (indicated horse-power is meant) are in charge of chief and artificer engineers, and are being run efficiently, and yet the Admiralty is flying to outside sources for the raw material for manning the higher ranks of the engine-room arm of the service and treating its well-tried men, such as those indicated above, with a coldness which is depressing and starving the feeders of the ranker element with a rate of pay that a girl munition maker would scoff at.

With the hope that other readers of your journal may take up this question, as this is no time for fiddling with the efficiency and smooth-running of the Navy,

I remain, yours,

Southsea. W. S.

GOVERNMENT EMPLOYMENT.

TO THE EDITOR OF ENGINEERING.

SIR,—The letter from Mr. W. H. Thorpe appearing in your last issue prompts me to write you my experience. Since the war I have been mostly engaged on war work, both for the War Office and Admiralty, and have been in close touch with many departments. It is amazing to a practical engineer like myself that many of these technical departments are run by men in uniform that in pre-war time were members of the legal profession, stockbrokers, sugar merchants, &c. I never but once met what I call an engineer, who could read or understand drawings, patterns, or methods of production, or even discuss the job with you in a practical way. Neither have I met anyone in office who could gauge a practical man and place him to advantage.

Under the National Service Act I registered in all Government departments, giving full particulars of my past experience, and what I had done and was doing for the Government at the time; from all these departments I never had one satisfactory reply—some did not even acknowledge my letters at all. From the Air Board I had a letter saying draughtsmen were badly wanted at a salary of 3*l.* 10*s.* a week for 48 hours, and no travelling expenses allowed, and if I should take up such an appointment I should be doing work of great national importance.

Now this war requires the services of all our practical engineers properly organised to win it. One is constantly being told the Germans are far more clever engineers than we are. There is one thing I do know, the Germans appreciate practical men before the legal profession; their technical departments are not run by barristers, lawyers and stockjobbers whose business went slump owing to the war, and who now hold commissions through influence to do work and control what they do not understand, but "swank they do," and, further, many of these gentlemen in office are evading military and naval services.

The Air Board is, moreover, a muddler in reference to building air engines and aeroplanes; they are only doing now what might have been done in the early stages of the war. To use Lloyd George's expression, "Too late here! Too late there!" coupled with mechanical ignorance. Let our Government remember this: the engineers of this country made England, Europe and the Empire. The engineer can build it up again—not barristers and legal gentlemen, who, in the past, have done all they could to bring it down for their own personal gain.

Yours faithfully,

"VULCAN."

July 10, 1917.

FUEL ECONOMY.

TO THE EDITOR OF ENGINEERING.

SIR,—In your issue of July 6, under the heading of "Notes," reference is made to large steam turbine plants, and to a paper presented by Mr. J. A. Robertson at the recent meeting of I.M.E.A. on "Fuel Economy." In this paper Mr. Robertson refers to higher steam pressures and temperatures than at present used, as a means of obtaining economy in fuel.

As the writer has been a consistent advocate of these means for securing fuel economy, and has designed and operated a plant of this nature for a considerable time at Rugby, perhaps you will permit the following information being put before your readers:—

At the British Association meeting at Dundee, 1912, Dr. Dugald Clerk read a paper on the gas turbine, and in the discussion following the paper the writer suggested that, whilst waiting for the gas turbine to become practicable, a good deal might be done to improve the economy of steam plants by using higher steam pressures and temperatures. He contended that a fuel saving of 15 per cent. to 18 per cent. was certain, and that experiments on a fairly large scale were about to be started to prove this contention.

The directors of the British Thomson-Houston Company, Limited, provided means for manufacturing and installing a plant of 1,500 kw. capacity, using extra high-pressure steam, and this plant was successfully put into commercial service about two and a half years ago.

Engineers interested in thermodynamics will know that for a given temperature the total heat required to be put into the steam decreases as the pressure goes up, and at the same time more heat is available for work. For readers not familiar with the properties of steam it may be of interest to see this relationship in the form of readily interpreted curves. The curves given below are based on adiabatic expansion, on the feed water entering the boiler at 80 deg. F., and that the expansion is taken down to a pressure equal to 28½ in. vacuum (barometer 30 in.). The efficiency-ratio shown on the curves is derived from the relation of:

$$\frac{\text{Heat available in steam}}{\text{Total heat in steam}}$$

From the curves, Figs. 1 and 2, it is seen that the improvement in efficiency is greater the higher the temperature. For instance, at 175 lb. absolute pressure an increase in temperature from 700 deg. to 800 deg. F. increases the thermal efficiency nearly twice as much as does the rise in temperature of from 400 deg. to 500 deg. F. The relationship of pressure and efficiency is also readily

Fig. 1. RELATIVE EFFICIENCY OF ADIABATIC EXPANSION FEED WATER TEMPERATURE 80° F. 28½" VACUUM.

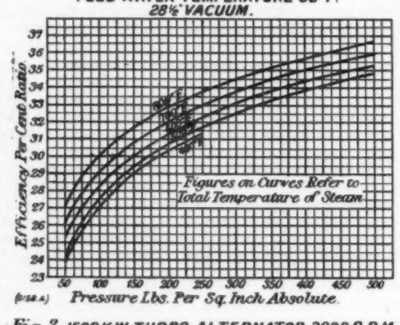
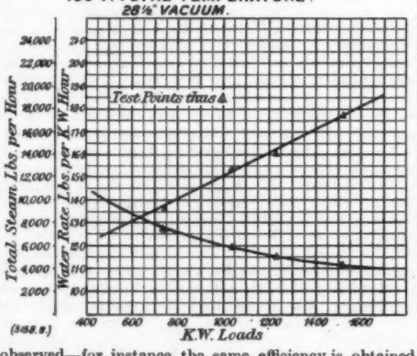


Fig. 2. 1500 K.W. TURBO-ALTERNATOR 3000 R.P.M. 350 LBS. PER SQ. INCH GAUGE 700° F. TOTAL TEMPERATURE. 28½" VACUUM.



observed—for instance, the same efficiency is obtained with steam at 300 lb. pressure and 500 deg. F. temperature as at 175 lb. pressure and 800 deg. F. temperature. The highest permissible safe working temperature of steam is about 800 deg. F. as applied to ordinary boiler, piping, and turbine material now in use. With the temperature limit thus given, higher economy can only be obtained by increasing the pressure.

When the experimental plant at Rugby was decided upon it was hoped that a pressure of 500 lb. could be used. After consultation with Messrs. Babcock and Wilcox a compromise pressure of 350 lb. was decided upon, the steam to be superheated to a total temperature of 700 deg. F. The capacity of the boiler was to be 18,000 lb. of steam per hour, and the type selected was the makers' well-known self-contained, marine type, with boiler, superheater and economiser sections inside one casing, and fitted with chain grate stoker and induced draught. The turbine, which is of the impulse type, was built to standard design modified to suit the new conditions. The generator is totally enclosed, and the air used for cooling is delivered to the boiler grate. The plant auxiliaries call for no special comment. The plant was first put into service at the end of 1914. Steam consumption tests have been taken, and the results are given on the curve (Fig. 2). The figures obtained include generator losses and excitation, but do not include power for the auxiliaries.

It should be stated that with a turbine designed especially for the high steam conditions an improvement in the steam consumption at full load of about 0.4 lb. per kilowatt-hour can be obtained, but this was not possible with the present machine because, as stated above, standard parts as were available in 1913 were used in its construction. Tests on the boiler show an efficiency varying from 80 per cent. to 83 per cent. To ascertain the actual consumption of coal per kilowatt-hour a 10 hours' test was taken, which gave 1.83 lb. of coal per unit generated, the vacuum obtainable being but 27.7 in. The average heat value of the coal as fired was 10,985 British thermal units per pound, or the equivalent to 20,000 British thermal units per unit generated. The mean heat value of the coal was ascertained from three average samples, tested by three independent laboratories, all agreeing very closely. The above coal consumption refers to the turbo-generator unit only, and does not include the power taken for auxiliaries, which could not be properly estimated, the circulating pump also supplying other condensers.

The new plant proved so successful and economical that it was put in commercial operation on the power circuit for the works. The saving in coal has exceeded the 15 per cent. to 18 per cent. already mentioned owing to the improved efficiency of the new plant under the constantly varying load and power conditions in a large works, though the older power plant is of comparatively modern construction. Only minor troubles have been met with either in turbine or boiler. Some parts were found unsuitable for the high temperature, and had to be renewed, but these have been of minor character, and have not interfered with the operation of the plant, and it may be stated that the turbine and boiler have passed out of the experimental stage. The plant was opened up and examined during the last Christmas holidays and found in good condition. As only three days were available, the inspection could not be as thorough as desired, and will be made again during the present month, when time will permit of a more careful examination. Should anything of interest be found, or faults discovered which would alter the writer's present opinion, he would like the hospitality of your columns to return to this subject.

The writer recently had occasion to look into a large power plant scheme with favourable load factor, and found that with a boiler pressure of 350 lb., steam temperature 750 deg. F., circulating water temperature 55 deg. F., the heat consumption per kilowatt-hour generated works out at 15,000 British thermal units, which includes a boiler efficiency of 80 per cent., with all losses in turbo-generator, but does not include power for auxiliaries. Allowing 6½ per cent. for the auxiliaries, the gross heat consumption per unit generated will be about 16,000 British thermal units.

Mr. Robertson in his paper anticipates a coal consumption of 1.45 lb. per unit sold, and with a good quality of coal this seems to be well within the possibilities of the art to-day.

Yours faithfully,

FREDERICK SAMUELSON.

Rugby, July 9, 1917.

BRITISH THERMAL UNIT.

TO THE EDITOR OF ENGINEERING.

SIR,—Most engineers must have been struck with the clumsiness of the expression "British thermal unit." If it is abbreviated to B.T.U. there is the further disadvantage that these initial letters are precisely the same as those for "Board of Trade unit" for electrical supply.

Would it not be possible to adopt a simple word to express our heat unit, in the same way as the word "calorie" expresses that on the metric system? I would suggest that we coin the word "therm" for this purpose. It would be quite suitable, and the symbol abbreviation Th. would still stand, as at present.

Perhaps the philologists may come down on me as being a coiner of barbarous words. I don't care. Therm would be a convenient word to express what is meant, and it does not matter whether it is *derived* in orthodox fashion or not. As a scientific term it would perhaps be all the better for having no other meaning attachable to it.

Yours truly,

G. L.

Parliament-street, Westminster, July 7, 1917.

THE MAGNETIC PROPERTIES OF MANGANESE AND MANGANESE STEELS.—At the meeting of the Royal Society held on June 28 a paper was read by Sir Robert Hadfield, F.R.S., Ch. Chéneveau and Ch. Géneau. "A Contribution to the Study of the Magnetic Properties of Manganese and of some Special Manganese Steels." (1) The research has had for its object the investigation of the mass-susceptibility of manganese metal, and of certain of its alloys with iron and other metals. The work was carried out on a Curie-Chéneveau magnetic balance. (2) Manganese itself, when free from occluded gases, is para-magnetic, its value of χ being $+ 11.0 \times 10^{-6} \pm 2$ per cent. This corresponds on Weiss's theory to a number of magnetons equal to 6. The removal of occluded gases is essential, as the ferro-magnetic properties of certain specimens of manganese is shown to be due to the presence of hydrogen. (3) The manganese alloys investigated, with one exception, are all para-magnetic, χ varying from 17.0×10^{-6} to 259.0×10^{-6}. The exception mentioned is a silico-manganese steel containing 6 per cent. of silicon, which is distinctly ferro-magnetic. (4) An endeavour is also made to correlate the values of the mass-susceptibility with the composition of the alloys. In this connection it has been shown that the quantity of manganese within the limits investigated has very little influence upon the susceptibility, whilst increase of carbon tends to decrease it. In general it is concluded that in these special steels the susceptibility decreases as the carbon-manganese ratio increases. (5) The carbon-manganese ratio being constant, addition of chromium, nickel or tungsten raises the susceptibility. (6) The addition of copper to a manganese-nickel steel also raises the susceptibility—this notwithstanding the diamagnetism of copper.

AUTOMATIC DRILL CHUCK.

CONSTRUCTED BY MESSRS. LOUIS WEARDEN AND GUYLEE, LTD., ENGINEERS, BRADFORD.

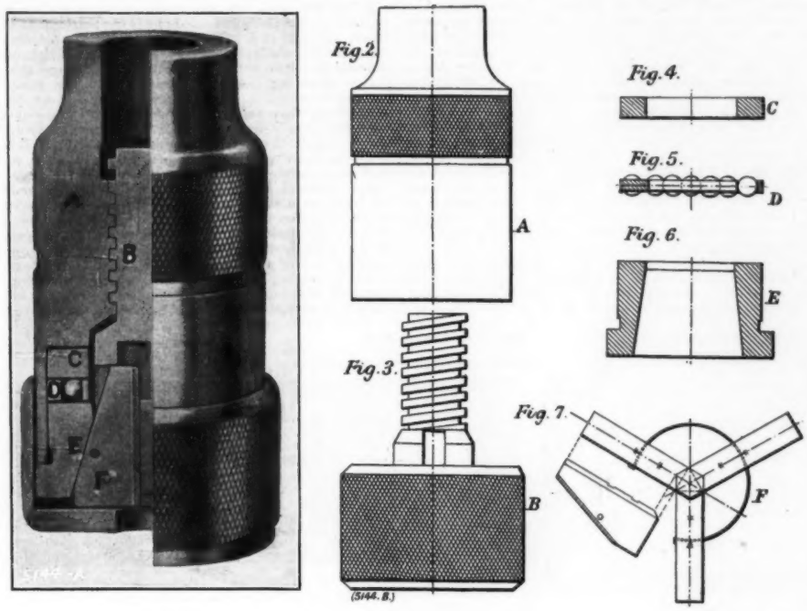


FIG. 1.

WE illustrate on this page a drill chuck which is now being manufactured in quantity by Messrs. Louis Wearden and Guylee, Limited, of Snowden-street, Bradford, most of the work being done by female labour. The tool illustrated will take any size of drill shank from 0 in. up to $\frac{5}{16}$ in. in diameter. For small sizes of drills, chucks are, of course, practically indispensable, as straight shank drills in small sizes are more readily obtained and cheaper than taper shanks. The general arrangement of the chuck will be easily understood on reference to Fig. 1, whilst its component parts are shown separately in Figs. 2 to 7. The drill is held by three hardened steel jaws F, Figs. 1 and 7, which are guided by slots cut in a stem which is permanently screwed into the knurled head of the component B. The backs of the jaws F abut on the hardened steel ring E, which, in turn, bears on the ball thrust D, Fig. 5. A hardened collar C is provided to transfer the load to the component A. This component A is screwed with a square thread, to take the screwed end of the component B. The chuck is self-tightening. When the drill is at work the torque on it tends to screw B further into A, thus causing the jaws F to grip the drill still more tightly.

Owing, however, to the use of the ball thrust the chuck never jams, but can always be easily loosened, and drills are readily removed and replaced without stopping the machine. One user reports that at his works this is done even when the speed is as high as 1,000 r.p.m. The chuck has no projecting parts whatever, and no screws of any kind are used to keep it together. This end is attained by the use of split rings of hard wire sprung into place. For instance, the component B is prevented from unscrewing completely and thus disassembling the chuck, by means of a wire which fits under an internal lip formed at its upper edge. Sufficient clearance is provided between this lip and the body of the component A to allow the wire to be sprung into place. The diameter of the wire is such that it then projects slightly beyond the lip above-mentioned and cannot pass over the shoulder of E, which projects slightly beyond the outer surface of component A. A similar system is used to retain in place the ring E.

Every part of the chuck subject to pressure or wear is hardened, and all parts are made interchangeable, being finished by precision grinding to very small limits of error. A shank having a Morse taper at one end and a fine taper fitting the hole at the top of the chuck is provided for adapting the chuck for use in ordinary drills. The same chuck can thus be used on any drilling machine by changing the shank with, say, a No. 1 Morse taper for another with, say, a No. 3 Morse taper, or whatever other standard taper the new machine may require. Straight shanks are also provided, and for turret lathe work the chuck is constructed with a long parallel shank to fit the hole in the turret.

ACTIVATED SLUDGE PROCESS OF SEWAGE PURIFICATION AT WORCESTER.*

By Mr. THOMAS CAINE, Assoc.M.Inst.C.E., City Engineer.

IN December, 1914, a deputation from the Corporation of Worcester, including the mayor, Alderman H. A. Leicester, and the members of the Water and Sewerage Committee, with some other members of the City Council, visited the Salford Sewage Works to see the activated sludge process of purification, which was experimentally in operation there. Mr. Mellin, the chemist, and Mr. Duckworth, the manager of the works, kindly met the visitors and explained to them the process. The deputation had the further privilege of being accompanied by Dr. Fowler, of Manchester University, from whose investigations the process is mainly the outcome. The deputation was greatly impressed with the simplicity and compactness of the purification arrangements, as well as with the effluent produced, but as no particulars of the consumption of air required and other items of cost were then available, the City Council was content to await further developments of the process.

The method experimented with was an intermittent one, known as the "fill and draw" method. The writer was impressed with the conviction that until a continuous method was devised, which did not appear to be a very difficult proposition, the process was not likely to receive general acceptance. The position was not greatly dissimilar to that which obtained twenty years ago. At that time the intermittent method of bacterial purification by contact beds had spread pretty widely. The author was at that time convinced that superior results would be achieved if the bacterial filtration could proceed continuously by percolation. He accordingly devised the self-propelled distributor, which was introduced to the engineering world under the title of the Candy-Caink distributor. This device made practicable the continuous percolating filter, which, by its extremely wide adoption for sewage purification, has shown that the anticipations which the author entertained were amply justified. A similar development has now been made with the activated sludge process, and with similar beneficial results, both in capital outlay as well as running costs. It is the continuous method of this treatment that has been experimented with at the Worcester sewage works during the past twelve months.

Messrs. Jones and Attwood, in company with Dr. Fowler, visited the Worcester works, to ascertain if the sewage tanks could be conveniently adapted to the arrangements they had designed for giving effect to the continuous method. Dr. Fowler thought the tanks were ideal for the purpose. The firm accordingly approached the City Council with a proposal upon the "no cure, no pay" principle, which was finally accepted by the council and embodied in an agreement. The firm was given possession of two-thirds of one of the tanks, which were in duplicate, to make what alterations they thought necessary, and if the experiments were successful they were to be paid, at the expiration of twelve months a sum mentioned in the agreement. If not successful, they undertook to remove their plant, &c., and restore the tank to practically its original state.

The experiment was to be regarded as a success if, without causing any nuisance or offence, it treated 750,000 gallons per day dry weather flow, and twice that quantity wet weather flow, so that the resulting effluent should be incapable of putrefaction, and contain not more than four parts by weight of suspended matter in 100,000 parts of effluent. The firm was also required to submit to the city engineer for his perusal, but not for his approval, drawings showing the arrangements they proposed to adopt. It will be understood from this that, whatever merit there is in the scheme, which the association will have the opportunity of inspecting, the credit thereof belongs entirely to Messrs. Jones and Attwood, and in no sense to the author, with the exception, perhaps, of some details suggested by him.

It was obvious that if the activated sludge process of purification was to become one which sewage engineers could entertain, the quantity of air used in the Salford experiment when the deputation visited those works must be greatly reduced, so as to bring the cost of pumping air within reasonable limits, and, as has already been remarked, it was extremely desirable that a continuous method should be found. The experimental plant at Worcester is an effort to give effect to these two desiderata.

It was clear from the investigations of Dr. Fowler and others that the purification was effected by keeping the activated sludge, which held the myriads of oxidising organisms, in intimate contact with the liquid to be purified, and by keeping the organisms supplied with a sufficiency of oxygen from the air. Hence the more finely the sludge was broken up, and the more evenly it was distributed throughout the mass of liquid, the more intimate was the contact between the solids and liquid. The question, therefore, became, What is the most efficient method of producing fine subdivision and suspension of the solids?

Nothing seemed so effective to this end as agitation of the entire mass of liquid and solids by the blowing in of atmospheric air, while this method possessed the further advantage of supplying the necessary oxygen to the organisms. As the need of the latter requires only a fraction of the air demanded for the former, the economical problem becomes reduced to one of devising a method of suspending the sludge throughout the mass of liquid with the minimum consumption of air. The plant installed at the Worcester Sewage Works is Messrs. Jones and Attwood's contribution towards the solution of this problem.

It will easily be seen from what has been said that it is important to remove detritus and all other heavy matter in the sewage before passing it into the aeration tank. All large, suspended, non-putrefactive, organic matter should also be screened, and as these substances neither need purification themselves nor contribute to the purifying process, they are "matter in the wrong place," and should be eliminated.

The portion of the tank handed over to Messrs. Jones and Attwood for their experiment had a net water capacity, at a depth of 17 ft. 3 in., of 626,000 gallons. It consisted of a rectangular tank, 86 ft. 3 in. by 78 ft. by 18 ft. deep from coping to floor. It was divided into nine longitudinal bays extending from the inlet channel, which ran across the entire width of the tank, to its opposite end, by eight division walls, 9 in. thick, all the bays having a water communication between them at the lower or outlet end. These longitudinal bays were subdivided by three transverse walls, finally forming 36 rectangular bays, each 21 ft. long by 8 ft. wide and 18 ft. deep. Of these, 20 are devoted to aeration, 8 to the settlement of the sludge, and the remaining 8 are at present not in use.

Reverting to the Salford tank, the arrangement for aeration consisted of air pipes laid on the floor of the tank, which was flat, containing perforations for the exit of air spaced about 1 ft. apart. Any material increase in the distance between the air exits was found to result in the settlement of sludge on the floor in the intervening spaces.

For the purpose of increasing the intervals between the air jets, and to avoid the piling up of sludge on the floor of the tank, a series of concrete ridges and furrows have been constructed over the entire floor area of the aeration tank, the ridges occupying the spaces on which the sludge would accumulate if the floor were flat. In the furrows porous tiles, called "diffusers," are laid, through which the air is delivered to the liquid. The author thinks these are a distinct improvement upon the plain jets. By means of these ridges the distance between the air outlets have been greatly increased.

In the first longitudinal set of bays, which receives the raw sewage, the rows of diffusers, which run across the bays and are 1 ft. in width, are separated by a distance of 5 ft. By these diffusers a vertical circulation of the water is set up, returning upon itself, while the air escapes at the surface. In the remaining aeration bays a somewhat different arrangement of ridging has been adopted, whereby the distance between the rows of diffusers is increased to 10 ft., thereby reducing the consumption to one-half of the former series for a given area of tank. Each row consists of eight diffusers, each 1 ft. square, laid transversely across the bay. The circulation resulting from this arrangement, instead of being local to each row of diffusers, as is the case in the first longitudinal bay, is that the air drives the liquid forward.

Advantage is taken of this to create a horizontal

* Paper (slightly abbreviated) read before the Association of Managers of Sewage Disposal Works on July 7.

circulation around two contiguous series of longitudinal bays; a portion of the water returns, and a portion is taken by the next pair to travel in a horizontal circuit in these. From these the now oxidised liquid, containing its full complement of suspended sludge, passes into the settling bays. These eight bays are formed into four tanks, having their floors shaped into inverted pyramids sloped at an angle of 60 deg. from the horizontal. At the apex of each pyramid a sludge lift is provided, consisting simply of a 6-in. pipe, in the bottom of which a stream of air is blown, which raises the settled sludge and discharges it into an 8-in. horizontal sludge main, which conveys it into the inlet channel, where it mixes with the incoming raw sewage and returns to the aeration tank, the excess sludge being drawn off and conveyed to sand beds for drying and disposal.

The sludge as it leaves the settling bays contains usually about 95 per cent. of water, in addition to a considerable quantity of free water, which rapidly drains away. The purified effluent is decanted from the settling tank into troughs, which convey it to the effluent channel. The total net capacity of the aeration bays affords an aeration period of 6 hours, with a rate of flow of 1,000,000 gallons per 24 hours, plus 20 per cent. of sludge. The settling bays give a detention of 1 hour and 40 minutes for the same rate of flow, but without the sludge. The actual quantity treated per diem is usually 750,000 gallons, which gives 8 hours' aeration and 2½ hours' settlement. With these flows the conditions of the agreement in respect of the dry weather flow are complied with. Annexed are analyses of the inflow and effluent. So far as experiment has proceeded the requirements relating to the wet weather flow have not been fulfilled with respect to the suspended matter, the settling area being apparently insufficient.

ANALYSIS.

Analysis of Screened Sewage taken May 31, 1917. Worcester Sewage Works.

	Parts per 100,000.
Solids in suspension	10.4.
,, solution dried at 100 deg. C. ...	151.0.
,, ,, appearance	Brown.
,, ,, after ignition	132.0.
Behaviour of solids in ignition	Blackening and bad odour.
Phosphates	Trace.
Chlorine calculated as common salt	68.9.
Free and saline ammonia ...	2.0.
Albuminoid ammonia... ...	0.57.
Oxygen absorbed in 4 hours ...	2.1.
Nitrogen in nitrates and nitrites	None.
Colour	Opalescent.
Deposit	Dark grey.
Smell	Bad.

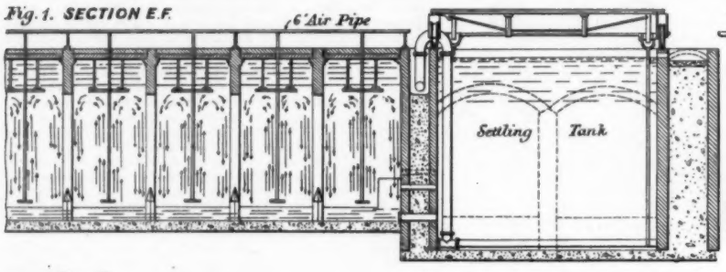
(Signed) R. NIND.

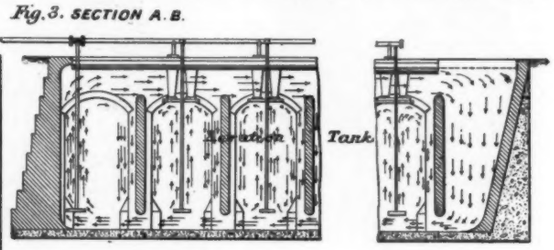
The air compressor supplied with the plant for aeration is a double-acting reciprocating machine, designed to deliver 562 cub. ft. per minute, with a speed of 235 r.p.m., and is driven by a 40-h.p. direct-current motor. The quantity of air delivered seemed greater than was needed; the speed of the machine was, therefore, reduced, by increasing the diameter of the motor pulley, to 150 revolutions, yielding (not counting slip) 416 cub. ft. per minute, with a consumption of electricity of 365 units per day. The reduction of speed doubtless diminished to some extent the efficiency of the air-compressing plant. The air is conveyed to the tank through a cast-iron main, 9 in. diameter, from which 5-in. and 4-in. branches are taken along the coping courses of the division walls. From these, wrought-iron tubes, 1 in. and 1¼ in. diameter, are carried to the diffusers, which are laid upon the floors of the tank, between the ridges.

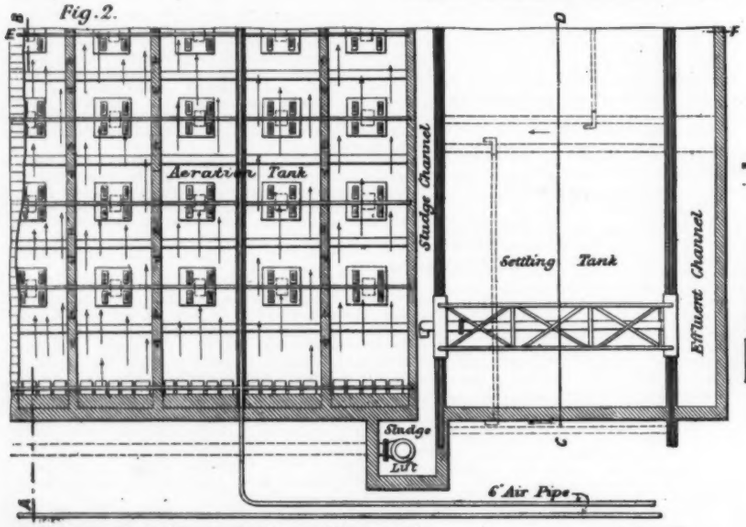
The total area of the diffusers, each of which is 12 in. square, is 313 sq. ft., being about one-tenth of the water area in the aeration tank. The pressure of air at the compressor is 9 lb. per square inch; the quantity of air used is 0.8 cub. ft. per gallon of sewage; the price paid for electricity is ¼*d.* per unit; the consumption of electricity for the air supply is 488 units per 1,000,000 gallons; and the cost, at the price paid, 30*s.* per 1,000,000 gallons treated.*

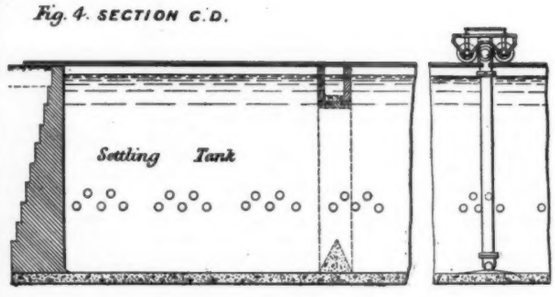
The air compressor should be in duplicate, so that the aeration may not be suspended in the event of the machine requiring repairs. Probably the most economical arrangement would be to divide the compressor plant into three units, one having a capacity equal to the maximum air required, another of 75 per cent., and the third of 50 per cent. of the maximum. Observation of the running of the plant affords evidence that the quantity of air used is capable of oxidising a greater quantity of sewage than the above figures indicate.

It has been said that the sludge problem is the sewage problem; that the solution of one is the settlement of the other. If that is so, then the author is of opinion that the activated sludge process is the solution of the sewage disposal problem, because, whatever fertilising value the sludge resulting from the process may nor may not possess, it is an innocuous material, and may be deposited anywhere without offence. That it does possess important fertilising properties is unquestionable, but how to apply it most economically to the land is open to much consideration. It appears to the author, so far, that after simple air drying for a few weeks in very thin layers it could be conveyed by mechanical traction to the land, to distances which would ensure a profitable return for the expenditure, without causing the least offence. If that proves to be the case, the importance of the process will eventually be enormous from the point of view of production of food crops. The character of the Worcester sewage is a fairly average one from the domestic and manufacturing point of view. The city is entirely water-closeted; a considerable portion of, but by no means all, the surface water is separated from the sewers, and there is a variety of manufactories, comprising breweries, porcelain works, glove works, tanneries, chrome leather works, engineering works, foundries, tinplate works, and others.









ANALYSIS.

Analysis of Sewage Effluent from Worcester Sewage Works, taken May 31, 1917.

	Parts per 100,000.
Solids in suspension	Trace.
,, solution dried at 100 deg. C. ...	143.0.
,, ,, appearance	Brown.
,, ,, after ignition	126.0.
Behaviour of solids in ignition	Blackening and bad odour.
Phosphates	Trace.
Chlorine calculated as common salt	67.7.
Free and saline ammonia ...	2.6.
Albuminoid ammonia... ...	0.17.
Oxygen absorbed in 4 hours ...	0.56.
Nitrogen in nitrates and nitrites	None.
Colour	Slightly opalescent.
Deposit	Slightly brown.
Smell	Slight.

Dissolved atmospheric oxygen absorbed in five days (Adeney's test) = 0.63 parts per 100,000.
No putrefaction observed in five days (incubation test).
Remarks.—The above effluent is satisfactory.

(Signed) ROL. NIND.

* 10 per cent. has been added to the price of current since the war began, which makes the cost 33*s.* per 1,000,000 gallons.

It has been said that the sludge problem is the sewage problem; that the solution of one is the settlement of the other. If that is so, then the author is of opinion that the activated sludge process is the solution of the sewage disposal problem, because, whatever fertilising value the sludge resulting from the process may nor may not possess, it is an innocuous material, and may be deposited anywhere without offence. That it does possess important fertilising properties is unquestionable, but how to apply it most economically to the land is open to much consideration. It appears to the author, so far, that after simple air drying for a few weeks in very thin layers it could be conveyed by mechanical traction to the land, to distances which would ensure a profitable return for the expenditure, without causing the least offence. If that proves to be the case, the importance of the process will eventually be enormous from the point of view of production of food crops. The character of the Worcester sewage is a fairly average one from the domestic and manufacturing point of view. The city is entirely water-closeted; a considerable portion of, but by no means all, the surface water is separated from the sewers, and there is a variety of manufactories, comprising breweries, porcelain works, glove works, tanneries, chrome leather works, engineering works, foundries, tinplate works, and others.

When Messrs. Jones and Attwood submitted the drawings showing the alterations they proposed to make to the tank to adapt it to the process they were going to experiment with, the author was impressed with the conviction that more energy—mechanical, chemical and bacterial—might be obtained from the air used if, instead of allowing it to escape into the atmosphere immediately on its reaching the surface of the water, it were made to travel horizontally, carrying with it a stream of liquid for a distance, by covering the tank with a more or less airtight roof. He accordingly submitted to the firm a design for an aeration tank upon those lines, as well as a settling tank by which, he conceived, superior effects would be obtained for a given quantity of air supplied to the liquid. He has since then further developed the scheme along the same lines, and ventures to submit a description and drawing of it for the consideration of the association.

The objectives sought to be reached are :—

Aeration Tank.

1. Prolonged contact between air and liquid.
2. Simplicity and moderate cost of tank construction.
3. Suspension and fine subdivision of the solids, and aeration with a minimum expenditure of air.
4. Impossibility of short-circuiting of the liquid from inlet to outlet.
5. Facility for draining tank in the event of its requiring to be emptied.

6. Easy removal of air diffusers for examination and changing.

7. Facility for observing progress of purification in the transmission of the liquid from inlet to outlet of aeration tank.

8. Adaptability to variations of flow from minimum dry weather to maximum wet weather, and from day flow to night flow.

Settlement Tank.

10. Uniformity of forward movement of the entire volume of effluent, so as to obtain the maximum settlement of sludge with the minimum tank capacity.

11. Certainty of early and complete removal, and restoration to aeration tank of the deposited sludge.

12. Adequate length of weir over which the final effluent flows to its destination.

The engravings on page 50 illustrate a part of a tank designed to deal with a dry weather flow of 2,000,000 gallons of sewage, and a wet weather flow of 6,000,000 gallons per day. This would provide for a population of 50,000, with a water consumption of 40 gallons per head per day. The internal dimensions of the aeration tank are 86 ft. 9 in. and 18 ft. deep from coping to floor, and it has a net capacity of rather more than 650,000 gallons with a depth of water of 17 ft. This capacity gives an aeration period for 2,000,000 gallons per day of 6 hours, and for 6,000,000 gallons per day of 2 hours, assuming a sludge proportion of 25 per cent. of the entire volume.

The tank is divided into 10 longitudinal bays by walls running the whole length of the tank, the walls having their lowest course 1 ft. 6 in. above the floor, and the top courses 2 ft. 6 in. below the water-line. Nine of these bays are covered by a more or less airtight roof, carried by arches resting upon the division walls. The best material for this will probably be ferro-concrete, but in the drawing appended the roof is shown constructed of timber, composed of 11-in. by 4-in. planks rebated at their edges so as to form a joint ½ in. wide, intended to be filled with soft bitumen. This arrangement would facilitate the removal of any part of the roof for reviewng the air diffusers when necessary, or for other purposes. One of the longitudinal bays is left uncovered for the exit of the air used for circulation and aeration.

A row of diffusers, which are suspended by wrought-iron tubes from the cast-iron air main running above the roof, extends along the entire length of the bay, at the opposite side of the tank, to that of the unroofed bay. Other diffusers, similarly suspended, are distributed over 80 other bays, at distances apart of about 8 ft., in all directions. Over each of the latter diffusers a shield or deflector, 6 ft. square, consisting of elm boards submerged 3 ft. below the roof, is suspended (Figs. 1, 2, and 3).

In the wall separating the aeration from the settling tank a number of openings for conveying the liquid from the former to the latter are provided.

The dimensions of the settling tank are 86 ft. 9 in. long, 23 ft. wide, and 21 ft. deep. The depth of water from the crest of the overflow weir, which is level with the underside of the roof of the aeration tank, is 20 ft. The settlement tank is unroofed, its capacity is 250,000 gallons, and gives a settling period of 3 hours for 2,000,000 gallons per day. The floor is flat over its entire area. A siphon, having its horizontal limb about 3 in. above the floor, stretches across the length of the tank, its vertical limb, which is 10 in. in diameter, discharging into a channel running between the aeration and the settling tanks. The horizontal limb is perforated, and carries a series of scrapers pivoted upon a rod below the pipe, the other ends resting on the floor (Fig. 4). The siphon is suspended from a pair of wheeled carriages which run upon steel rails, laid on each side of the tank, upon trunnions, whereby the submerged portion of the siphon may be easily lifted to the surface for examination and removal of the scrapers when necessary, without emptying the tank or otherwise interfering with the continuity of the operation. A small electric motor mounted upon one of these carriages drives the siphon through speed-reducing gear to and from end to end of the tank. This is probably the most convenient form of drive, but generally there would be ample power in the flow of the effluent to give motion to the siphon, without the small expenditure of electricity. The effluent weir runs the entire width of the tank, and conveys the water to a channel which discharges into a culvert, conveying it to the river.

The action of the plant will have been anticipated from its description. The tank is filled to the underside of the roof from the inlet channel with raw sewage, admitted through nine openings spaced at regular intervals along the channel. Air is blown through the diffusers into the liquid, but instead of immediately escaping at the surface into the atmosphere, it is forced along under the roof to the only exit at the opposite end of the tank in a stream of water which flows at a velocity depending upon the volume of air transmitted through the diffuser. As this is happening throughout the whole length of the tank from inlet to outlet, the upper layer of water over the entire area is set in motion in the same direction from the diffusers to the opposite side, where the uncovered portion of the tank offers an escape for the air.

The stream of water creates a head at this point, setting up a return current, the intervening walls forcing the stream to flow along immediately above the floor with a scouring velocity, effectually preventing the lodgment of solid matter thereupon. A moving belt of water is thus created over the entire area of the tank. As, however, the sewage is constantly entering the tank and moving towards the outlet, each particle of water in the belt will assume the direction of a spiral or screw, the pitch of which will depend upon the relative velocities of the forward motion, due to the inflow, and of the circumferential motion, due to the influx of air, and, by this spiral motion, eventually reach the settling tank.

The openings which convey the raw sewage from the inlet channel into the tank are placed at such a level as to be near the middle line of the upper moving belt of water. The sewage, therefore, is immediately caught in the vortex and carried round the spiral stream, thereby preventing the possibility of short-circuiting, that is, of taking a more or less direct course to the outlet.

It will be seen that the mass of liquid lying between the moving zones is more or less stationary. In order to give motion to this water sufficient to keep the solids in suspension, and to give an adequate supply of air to the organisms, the isolated diffusers are provided. The air from these rises through the liquid and is deflected by the shields escaping at their edges, contributing more air to that in the upper layer and adding to the velocity of the moving liquid, at the same time causing a local crater-like circulation of the water to be set up by each diffuser. It will be noticed that there are three distinct motions given to the liquid—the flow from inlet to outlet, the circumferential motion, and the crater-like motion—the actual movement forward being compounded of all three.

The question may be asked, What is the most economical depth for the aeration tank? The following theoretical considerations may be of service in answering this question, although the actual depth which may be economical for any particular case will, of course, greatly depend upon the circumstances of the site and the nature of the ground encountered. The energy expended in creating a velocity of current is almost entirely absorbed by friction. Hence the shorter the distance the stream has to flow, the smaller is the friction developed for a given velocity, and consequently the less the energy absorbed in overcoming it. The form of rectangle of a given area which has the shortest periphery is, of course, the square; hence a rectangular tank which would offer the least friction to the circumferential current, in the method last described, is one of which the depth would equal its breadth.

In practice, this would generally be out of the question, because a tank 100 ft. wide would have to be 100 ft. deep. But the consideration shows that, other things being equal, the deeper the tank the less loss of power in circulating the water at a given velocity. Take the following example. In a tank of a width of 100 ft. and a depth of 10 ft., the water would travel 10 + 100 + 10 + 100, total 220 ft. In a tank of the same capacity, 50 ft. wide and 20 ft. deep the water would travel 20 + 50 + 20 + 50, total 140 ft. The difference in the energy required to overcome the friction for the same velocity of current in these cases would be appreciable.

In considering adaptability to variations of flow, it is clear that a tank capacity, both for aeration and settlement, must be provided to deal with the maximum quantity intended to be treated, and that the entire sludge content of the aeration tank must be kept active by maintaining alive the oxidising organisms, and that can only be done by a more or less continuous supply of air.

Experience has shown that a more diluted sewage does not demand so long a period of aeration as a stronger one. It may provisionally be taken that double the tank capacity which is required for the dry weather flow will suffice for three times that flow diluted with storm-water. Hence, if the full capacity of the tank capable of dealing with the maximum flow be used for the dry weather flow, it follows that it will receive twice the aeration period in its transit through the tank that it needs.

The "fill and draw" method of the activated sludge process showed that adequate activity of the sludge could be maintained by intermittent aeration, provided the period of rest was kept within certain limits. Two hours seemed to be quite a practicable interval. By the arrangement which has been described, advantage may be taken of this circumstance to employ one-half of the tank at a time for the dry weather flow, alternating the two halves at short intervals, of, say, half an hour or less. This can be easily effected by carrying a separate air main from the compressor to each half of the tank, and controlling them by a three-way valve. This might be operated either by hand or automatically through an electric motor by a timing arrangement. If the latter be adopted, the intervals of change might be made still shorter. This principle might be extended to adapting the consumption of air to variations due to a day and night flow.

The total area of diffusers, each of which is 15 in. square, is 220 sq. ft., being one twenty-ninth of the water area. With an initial pressure of 9 lb. per sq. in. the consumption of air with this area of diffusers would be 0.22 cub. ft. per gallon of sewage treated. The consumption of electricity for the air supply would be about 174 units, which at ½d. per unit amounts to 10s. 8d. per 1,000,000 gallons for the dry weather flow, and less for the wet weather flow.

These figures are based upon an aeration period of six hours. If three hours' aeration suffice, which is frequently found to be the case, then the method of alternate working of the two halves of the tank previously mentioned might be adopted. In that case the cost of the air supply would be reduced to 5s. 4d. per 1,000,000 gallons. These costs would, of course, be further reduced in the proportion in which the power production costs may be diminished.

For large installations probably the steam turbine driving a turbine air compressor would prove the most economical. In other instances high-compression types of oil engines or suction gas-producer sets would have the advantage.

Having regard to the comparatively small capital outlay involved in installing a fully-equipped plant for the process, the author believes that no other method of sewage purification will for economy approach that of the activated sludge process, and from the point of view of freedom from the risk of nuisance is probably not equalled, and certainly is not surpassed. To give any period of aeration that may be determined upon, 25 per cent. should be added to the net capacity of the tank which would provide that period, in order to allow for the volume of sludge present, upon which the purification mainly depends.

The quantity of wet sludge is, in this scheme, assumed to be 25 per cent. of the total volume. This quantity generally takes from two to three months to accumulate. The aerated liquid, mixed with its full complement of suspended sludge, passes into the settling tank through a number of openings in the portion of the wall situated between the two rapidly-moving belts of water. This arrangement has the effect of giving a slow forward movement to the entire mass of liquid in the tank, thereby ensuring the maximum settlement of the sludge. The latter is drawn away through the perforations into the horizontal limb of the siphon, and discharged into the sludge channel, which conveys it to a well, from which it is lifted by an air sludge lift into the pumping main conveying the raw sewage, with which it gets intimately mixed and returned to the aeration tank.

The author has designed a sludge lift which possesses the advantage of avoiding the semi-intermittent pulsating action common to air lifts, and also of indicating the density of the sludge lifted. This latter is important, because while it is imperative that all the sludge should as rapidly as possible be removed from the settling tank, it should, for economical reasons, be accompanied by a minimum quantity of free water. The device enables the density to be kept under easy observation, and consequently the proper quantity of air required for lifting the sludge readily ascertained and controlled.

At the opposite end of the sludge channel to that of the well a valve is provided for drawing off the excess sludge for disposal. This is conveyed through a drain to the drying beds. A settlement period of about two hours seems to be sufficient in most cases. The drawing shows a part of a tank of a capacity equal to three hours' dry weather flow of 2,000,000 gallons per day, and would give one hour for three times the dry weather flow. Whether this would suffice for the wet weather flow would largely depend upon the size and character of the stream into which the effluent would be discharged. The above arrangement assumes that the sewage has been previously efficiently screened and freed from detritus.

THE MINERAL RESOURCES OF GREAT BRITAIN.—The Board of Agriculture and Fisheries desires to give notice of the publication of a second edition of Vol. IV of the Special Reports on the Mineral Resources of Great Britain, which have been prepared by the director of the geological survey in response to numerous inquiries that have arisen through the conditions brought about by the war. In the main it is a reprint of the first edition, wherein the properties, sources and uses of fluorspar, and details of all workings in Britain, active and inactive, are given. Its price is 9d. Copies may be obtained through any bookseller from Messrs. T. Fisher Unwin, Limited, 1, Adelphi-terrace, London, W.C. 2, who are the sole wholesale agents to the trade outside the County of London; or from the Director-General, Ordnance Survey Office, Southampton.

THE RAILWAYS AND THE COAL FAMINE.—The shortage of fuel and its excessive cost are making themselves more and more felt in almost every country. The revenue is suffering greatly and the service generally is much impeded. Both in Sweden and Denmark a number of trains, more especially fast trains, have been discontinued; in the latter country, for instance, the number of daily passenger trains has been reduced to less than half the normal, and fast or through trains are almost a thing of the past. As a result the trains are often overcrowded and unable to keep time. In Sweden the Board of the State Railways has just decided to propose a rise of at least 40 per cent. in the present goods tariff and a rise of 20 per cent. to 25 per cent. in the passenger tariff. The working expenses have increased to such an extent that the proposed rise in the rates has been found necessary in order to enable the State Railways to yield the calculated surplus of 21,000,000 kronor for the current year. The new rates will probably come into operation very shortly.

THE PENNSYLVANIA RAILROAD AND THE WAR.—Mr. George D. Dixon, vice-president in charge of traffic of the Pennsylvania Railroad Company, has announced that in order to conform with the recommendations of the Railroads War Board, issued from Washington, D.C., and calling upon all lines to readjust their services with a view to conserving fuel supply and increasing capacity for moving coal, food, Government materials and troops, the Pennsylvania Railroad will, in the near future, put into effect a general and quite extensive revision of its passenger train schedules. The final details are being worked out, and will be announced to the public promptly upon completion. The company will endeavour to accomplish this purpose in the following ways:—(1) By consolidating passenger trains wherever practicable, thus making one train unit serve the purpose of two or more; (2) by the entire elimination, in some cases, of trains on which the patronage is very small; (3) by reducing the number of restaurant cars, and in no case operating more than one restaurant car on a train; (4) by reducing the number of parlour and sleeping cars, and by decreasing or possibly discontinuing, the use of club and observation cars. The company expects, through these means, to cut down the movement of passenger trains, on its lines east of Pittsburgh, by a total of about 6,000 train-miles per day.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

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ELECTRICAL APPARATUS.

104,426. Sir W. G. Armstrong, Whitworth and Co., Limited, and W. H. Waddingham and J. H. Thain, Newcastle-on-Tyne. (5 *Figs.*) **Rotary Switches.** May 19, 1916.—This invention relates to a step-by-step quick make-and-break rotary switch in which a number of contacts are arranged round a circular arc and the switch is actuated by a handle and a brush holder is mounted loosely on the axis of the handle and is connected to it by a spring. Means are provided for preventing any movement of the brush holder until the handle has been moved a step, whereupon the holder is released and the spring causes it to resume its normal position relatively to the handle. According to this invention, such means consists of a spring-controlled rod capable of sliding in guides upon the brush holder and having at its outer end a projection or roller which normally rests in one of the notches of a circular arc until released by the action of an arm on the handle. 6 is the operating handle. 60 is an arm with double ends. 8 is a holder carrying three brushes engaging with contacts 9, the holder 8 being connected to the handle 6 by a spring 81. On the holder 8 is a rod 82 slidable in guides and having at its outer end a crosshead with

Fig.1.

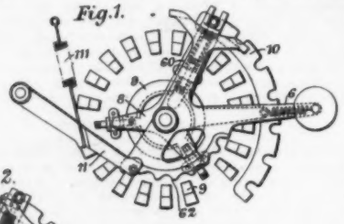
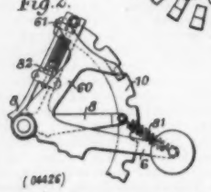


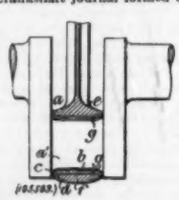
Fig.2.



rollers mounted upon it, the whole being kept in position by a spring mounted upon the rod 82. One roller normally rests in one of the notches in a circular arc 10, which notches correspond to the positions required. The arm 60 has upon it projections 61, 61 for engaging with the holder 8 as it begins to move in either direction, thus giving it a positive movement. Upon the handle 6 is a toothed sector 62, and a lever 11 is pivoted and acted upon by a spring 111 so that a roller at the end of the lever enters a recess between the teeth of the sector 62, thus ensuring that a definite step-by-step motion is given to the handle 6. To operate the switch, the operating handle 6 is moved a step, that is from the position shown in Fig. 1 in a clockwise direction to that shown in Fig. 2; by this movement the spring 81 is extended and the arm 60 is moved so that it acts on one of the rollers of the crosshead and lifts the crosshead against its spring until the other roller is out of its notch in the arc 10. The holder 8 being released, is quickly moved by the action of the spring 81, and the last-mentioned roller then enters the adjacent notch; at the moment that the last-mentioned roller leaves the first-mentioned notch the projection 61 on the arm 60 engages with the holder 8, giving it a positive movement. (*Sealed.*)

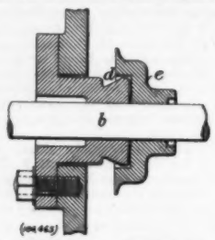
GAS ENGINES, PRODUCERS, HOLDERS, &c.

105,583. L. H. Pomeroy, and Vauxhall Motors, Limited, Luton. Crankshafts. (2 *Figs.*) March 21, 1916.—The invention consists in a solid crankshaft in which the pin or other journals work with separable bearings having hardened steel internal surfaces which co-act with journal surfaces formed of a layer of bearing metal adhering to the actual material of the shaft. The invention further consists in a separable steel connecting-rod end having a hardened internal surface for co-operating with a crankshaft journal formed of bearing metal



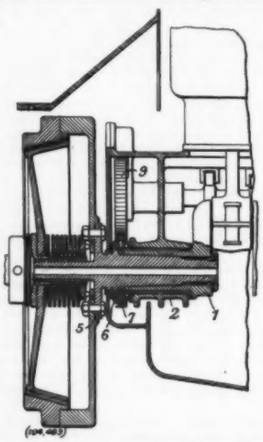
in the manner indicated in the preceding paragraph. A shaft *a* is only made of such dimensions in the crank-pin *a*1 and other parts as may be necessary to render the shaft capable of withstanding the bending and torsional stresses to which it is subjected irrespective of the increases necessary for eliminating torsional vibrations in multi-throw or extended shafts. A sleeve *b* of phosphor-bronze, having at each end projecting flanges *c*, *c* of suitable dimensions for forming abutments for the end surfaces *d* of the connecting-rod bearings, is cast upon the surfaces of the crank-pin journals, the rubbing surfaces of the liner and flanges being suitably machined to the desired dimensions. The connecting rod *e* and its cap *f* are constructed of case-hardening steel, which is suitably hardened upon the internal surface *g* of the bearing, and thus provides the desired combination of phosphor-bronze or other bearing metal and hardened steel co-acting with one another. (*Accepted May* 2, 1917.)

104,465. G. K. Davis, Manchester. Gas Washers. (1 *Fig.*) August 23, 1916.—The object of the invention is to provide improved means for preventing the leakage of liquid around the fanner shaft *b*, and to this end the invention consists in the provision, in connection with the fanner shaft *b*, within the washer, of a centrifugal device in the form of a disc *e*, which throws off the liquid adjacent to the side of the apparatus



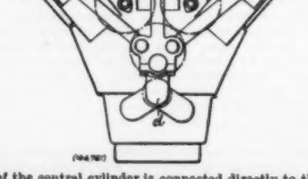
through which the shaft passes, in combination with a grooved boss *d* on the side of the apparatus through which the shaft projects, the said disc being almost in contact with the boss and partly encircling the same. It is found that the use of such an arrangement effectively prevents the leakage of liquid to the outside of the apparatus, and is particularly advantageous when used with apparatus for the dearsenication of sulphuric acid. (*Sealed.*)

104,493. F. H. Royce, and Rolls-Royce, Limited, Derby. Internal Combustion Engines. (1 *Fig.*) January 2, 1917. This invention relates to means for driving the camshafts of internal combustion engines from the flywheel end of the crankshaft. The engine crankshaft at the rear journal is made hollow, and fitting co-axial therewith is a shaft provided with flanges



towards its rear end for the purpose of carrying the flywheel and the timing gear wheel. The crankshaft 1 is bored taper through its rear journal to accommodate a shaft 2. The shaft 2 is provided with flanges 5 and 6, to which the flywheel and the timing gear wheel 7 are respectively secured. The wheel 7 drives the camshaft 8 through the medium of the gear wheel 9. (*Sealed.*)

104,761. Leyland Motors (1914), Limited, and A. Fergusson, Leyland. Internal Combustion Engines. (3 *Figs.*) March 29, 1916.—This invention relates to multi-cylinder internal combustion engines of the kind having a central cylinder and two lateral cylinders, the pistons of the three cylinders operating a common crank. A multi-cylinder engine, in accordance with this invention, comprises a central cylinder *a* and two lateral cylinders *b*, *c*, arranged one at either side of the central cylinder, and at angles of 40 deg. thereto, and a single centrally-disposed crankshaft *d* having a single crank. The connecting rod of the



piston of the central cylinder is connected directly to the pin of the crank, and the rods of the pistons of the two lateral cylinders are articulated on the big end of the rod of the piston of the central cylinder. The valves of the cylinders are operated from two camshafts *e*, *f* arranged between the central cylinder and the lateral cylinders, within the crank case, one shaft *f* serving to operate the valves of the central cylinder and one of the lateral cylinders and the other shaft *e* serving to operate the other lateral cylinder. Ignition may be effected in all the cylinders by a single magneto, but it is preferred to employ a separate magneto for each cylinder, and in such cases the three magnetos will be arranged concentrically around the crankshaft and driven therefrom by suitable gearing. Cooling may be effected by two circulating pumps, which may be mounted on, or in line with, the camshafts and be driven direct therefrom by suitable clutches, or a single pump, which may be driven direct from one end of the crankshaft, may be employed. (*Sealed.*)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

104,478. Albion Motor Car Company, Limited, and T. B. Murray, Scotstoun. Friction Clutches. (4 *Figs.*) November 3, 1916.—The invention relates to friction clutches in which there are two or more members rotating together, but relatively endwise movable for engagement and disengagement, and has for its object to provide between these a connecting means adequate to transmit the drive and at the same time sufficiently flexible in axial direction to permit of an easy engagement and disengagement of the parts. A device for this purpose made according to the invention consists essentially of two stellate annuli of thin and flexible material, the annular parts being

Fig.1.

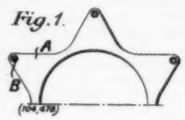
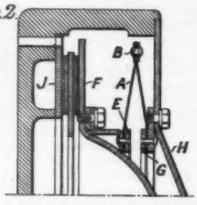


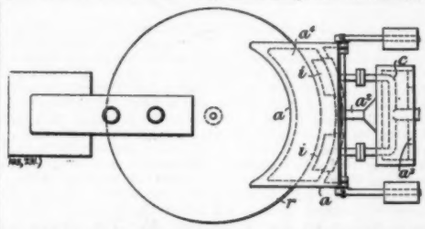
Fig.2.



radially narrow. The apices of the stellations may project either radially outwards or radially inwards, and are secured together by rivets or other convenient means. The ring parts formed by the adjoining bases of the stellations are secured the one to one member of the clutch, the other to the other member. The example of device shown in Figs. 1 and 2 consists of two stellate annuli, the stellations A of which extend radially outwards and are secured together at their apices by rivets B. In Fig. 2 one of the annuli of Fig. 1 is secured by a riveted ring E to the moving driving member F of the clutch, while the other annulus is similarly secured by a ring G to the cover-plate H of the other and non-moving driving member J of the clutch. (*Sealed.*)

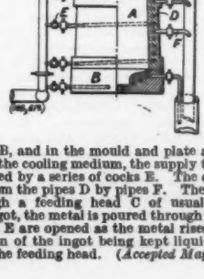
MINING, METALLURGY AND METAL WORKING.

105,731. Alldays and Onions Pneumatic Engineering Company, Limited, Birmingham, and R. R. McGowan, Lincoln. Metal Plate Working and Heating. (2 *Figs.*) December 27, 1916.—The invention consists in apparatus for heating and working metal plates, the apparatus being especially useful for heating and working metal plates or discs, such, for example, as boiler ends, preparatory to flanging the same. According to the invention, one or more gaseous fuel burners *i* are fitted in a box-like firebrick or firebrick-lined chamber *a* having a curved figure in plan and a slot in the curved or concave front face, so as to permit the edges of the circular plate or disc *r* to be heated to be passed through the said chamber



by rotating the plate or disc. The top a^4 of the chamber is hinged, and the chamber may be fitted with a waste flue a^2, whereby the waste heat and products of combustion may be conducted to a retort chamber a^3, through which passes the pipe *c* in which the liquid fuel for the furnace is vaporised or gasified, and in which the air to be mixed and burned with the vaporised or gasified liquid fuel is previously heated. It is preferred to employ, in combination with the apparatus described, a sectional press, that is to say, a press capable of operating on successive portions of the edge of the plate or disc under treatment as the same emerges from the box-like chamber or furnace. (*Accepted May* 2, 1917.)

105,617. Sir W. G. Armstrong, Whitworth and Co., Limited, and H. H. Ashdown, Newcastle-upon-Tyne. Casting Steel Ingots. (2 *Figs.*) April 20, 1916.—This invention relates to the casting of ingots of large size. According to this invention, ingots of large size are cast in a mould having a cooling medium circulating in its walls in such a manner that the sides of the ingot are quickly cooled and the segregates are driven into the centre of the ingot. A is a mould having a



bottom plate B, and in the mould and plate are pipes D for the circulation of the cooling medium, the supply to the various pipes being controlled by a series of cocks E. The cooling medium is discharged from the pipes D by pipes F. The metal is fed to the mould through a feeding head C of usual construction. In casting the ingot, the metal is poured through the feeding head C, and the cocks E are opened as the metal rises in the mould, the central portion of the ingot being kept liquid until the last by the metal in the feeding head. (*Accepted May* 2, 1916.)